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Thesis

Copepoda as intermediate hosts of helminths, with the description of two species from Borneo.

by

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I. Introduction

Most of the parasitic worms belonging to the Trematoda, Cestoda, and Nematoda complete their life-cycles by developing larval stages in insects, crustaceans, or other animals, and spending their adult stages in vertebrates. Among crustaceans, the order Copepoda is the important group as intermediate hosts of parasitic worms for several reasons. The Copepoda are cosmopolitan, living in fresh, salt, and brackish water. They can be distributed easily by wind, by birds, or by insects. They are also often distributed to great distances by washing out from lakes after heavy rainfall. Beal (1881) found half a teaspoonful of substance containing about 500 cyclops on the ground after a shower. Gjorjewic (1907) stated that the Diaptomidae of the Balkans are distributed by birds. _Diaptomus laticeps_ and _Diaptomus mirus_ have been carried from the north, and _Diaptomus salinus_ and _Diaptomus lilljeborgii_ have been carried from the south. Gurney (1931) found living copepods and Cladocera in streams miles from their source in the outflow of a lake. In addition to their distribution, Copepoda are of ancient origin, and they are important food for fish. They harbor larvae of different species of parasitic worms, and transmit them to their fish hosts. Tadpoles, anseriform birds, and other aquatic animals become infected by eating copepods harboring larvae. Some parasitic worms need two intermediate hosts. In this case, Copepoda may serve as first intermediate host. The final hosts become infected by

eating the second intermediate hosts, thus widening the range of distribution of the parasites.

II. Historical aspects

The fact that Copepoda serve as intermediate hosts of parasitic worms has long been known. Janicki and Rosen (1917) infected _Cyclops strenuus_ and _Diaptomus gracilis_ with coracidia of the cestode _Diphyllobothrium latum_ (Linnaeus 1758). Dollfus (1923) proved that copepods carry the larvae of the trematode Hemiurus. Leiper (1906) observed the larvae of the guinea worm, _Dracunculus medinensis_ Linnaeus, encysted in Cyclops. Hall's list (1929) of arthropods which serve as intermediate hosts of helminths summarized all previous work dealing with the life-histories of parasitic worms in relationship with arthropods. His paper showed that the Copepoda are predominant intermediate hosts for hymenolepids in birds, for proteocephalid tapeworms in fish, and also for diphyllobothriids in fish. Among the Crustacea, the Copepoda are the important group as intermediate hosts of nematodes. Hall's work is very useful, "in affording the student a clue as to the probabilities in beginning a search for the intermediate host of a heteroxenous worm parasite, or in considering the probably identity of a larval worm found in an arthropod."

These small, world-wide distributed crustaceans have had great attention. A study of Copepoda with accurate description was first made by Jurine (1820). Claus (1893)

established a series of subgenera in the genus Cyclops, which are, for the most part, accepted today. Classification of the Copepoda arranged by Giesbrecht (1899) implies a phylogenetic system, while Sars' (1913) arrangement is more convenient and adaptable. Kiefer (1929) proposed a detailed classification of the Cyclopoida, but the distinctions between both subgenera and species are too small. The result leads to confusion and uncertainty in identification. Gurney's British Fresh-water Copepoda (1933) contributes greatly to the taxonomy and morphology, based on Sars' system with some modification. As a whole the classification of the Copepoda is unsatisfactory, because the definition of many fresh water species is uncertain and because the development of many groups is unknown.

III. Materials and methods

I have had the opportunity to study two species of copepods from Borneo. These species were collected by Dr. A. G. Humes in 1945. The specimens together with other small aquatic organisms, debris, and sand were preserved in 70% alcohol.

The methods included the following processes:

1. Separation:

A small lump of sample from the original bottle was put in a Petri dish, diluted with 70% alcohol, and examined under a binocular microscope. The copepods were picked up by using a long fine pipette and preserved in a bottle

with 70% alcohol. The process was repeated, until the majority of copepods was separated.

2. Dissection and mounting:

A copepod was put on the center of a slide in a drop of alcohol large enough to keep it from drying. The copepod then was dissected under the binocular dissecting microscope by using pointed minuten nadeln. The dissection began by separating the 5th thoracic segment with the 5th pair of legs from the body. Then the rest of the body segments with their appendages and mouth parts were separated. All were mounted in polyvinyl alcohol. The formula of polyvinyl alcohol is as follows:

Polyvinyl alcohol stock solution	56%
Phenol	22%
Lactic acid	22%

3. Drawing:

In order to show accurately the features of the organisms, all figures were drawn with the aid of a camera lucida. The minute mouth parts were drawn under oil immersion.

In summarizing the literature dealing with the problem many scientific names of hosts and parasites were used by the original investigators without adding the author of the species as should have been done. I have supplied these author names in so far as possible, but, in cases where large amounts of time would have been involved in tracing the

synonomy of a name, the scientific name has been left without the author, and reference is made to the original paper.

IV. A supplement to Hall (1929)

The life-cycles of a few species of helminths will show the parts which copepods may play in their transmission and also show the experimental susceptibility of different species of Copepoda to different worms.

1. TREMATODA

Halipegus ovocaudatus (Vulpian 1859) and *H. eccentricus* Thomas 1939

These two species use frogs as their definitive host. The former lives under the tongue and the buccal cavity of frogs, the latter inhabits the Eustachian recesses of frogs. Thomas showed the eggs pass out with the faeces of the frog, and are eaten by snails of the genera *Physa* and *Helisoma*. The egg hatches and the miracidium penetrates the gut of the snail. It then transforms into a sporocyst containing eight rediae, each of which produces cystophorous cercariae about one month later. The cercariae leave the snail and are swallowed by the second intermediate host, *Cyclops vulgaris* Sars and *Cyclops obsoletus* Sars. The final host acquires the parasite when the tadpole ingests the infected copepods.

Lecithaster confusus Odhner 1905

Hunninen and Cable (1941) showed the cystophorous cercariae develop in the first intermediate host, marine snails of the genus *Odostomia*, and are eaten by copepods, *Acartia* species, which serve as the second intermediate host. The

metacercariae develop in the body of the copepod rapidly but do not encyst. A large number of marine fish including scomberiform fishes serve as hosts. The definitive host becomes infected by eating the infected copepods.

Cercaria sphaerula Thomas 1932

The cystophorous cercariae of this species were produced in the snail, *Helisoma trivolvis*, which was the first intermediate host. In laboratory *Cyclops vulgaris* Sars, the second intermediate host, ingested the cysts readily. Within 2 hours the larvae reached the body cavity of the Cyclops. The metacercariae of this group, including the *Cercaria californiensis* and *Cercaria projecta*, were noted by several observers to be free in the body cavities of marine and fresh water copepods. The cercariae enter the copepod by penetrating the carapace. Under natural conditions, *Helisoma trivolvis* may serve as the first intermediate host, and copepods as the second intermediate host. The marine copepods *Acartia clausi* Giesb. may also become infected through direct eating of cystophorous cercariae. By eating the infected copepods, fish, Beroe, Sagitta, medusae and other aquatic invertebrates may become the definitive hosts.

2. CESTODA

Ophiotaenia saphena Osler 1931

Proteocephalids were found in the intestine of the frog, Rana clamitans, in Michigan in 1931. Under natural conditions the frog is infested directly by eating the first intermediate host, an infected cyclops, or by swallowing the second intermediate host, an infected tadpole. In the laboratory, Thomas (1931) infested different species of Cyclops. Mesocyclops obsoletus, Sars, (C. leuckarti, Claus), Macrocyclops annulicornis Koch (C. albidus Jurine), and Cyclops vulgaris Sars (C. viridis Jurine), ingested the larvae. But the mature procercoids were found only in Cyclops vulgaris var. brevispinosus. The tadpoles also can be infested by feeding them infected Cyclops vulgaris Sars. It required 12-14 days for the mature procercoids to come into the body cavity of cyclops.

Crepidobothrium testudo

This species is parasitic in the intestine of soft-shelled turtles. Experimentally, Magath (1928) showed Cladocera and Diaptomus could not be infested. Cyclops bicuspidatus Claus ingested the eggs readily but no development took place, and Cyclops leuckarti Claus was the only one which contained the developing enchosphere. It took 6 hours for the onchosphere to reach the body cavity of Cyclops leuckarti. On the 7th day, the calcereous bodies appeared and they were very active. In 12-13 days the larvae became less active. There was

no further development after the 14th day. He suggested that under natural conditions Cyclops leuckarti is the first intermediate host. Soft-shelled turtle may acquire the parasite through ingesting the infected Cyclops.

Proteocephalus ambloplitis (Leidy), 1887

The adults of Proteocephalus ambloplitis have been found in 4 definitive hosts, Ambloplites rupestris, M. salmoides, M. dolmieu, and Amiatus calvus. The eggs are first eaten by a species of Cyclops. In the body cavity of Cyclops the eggs develop into procercoids. When a small fish eats the crustaceans the procercoids bore into the body cavity and encyst. The larvae get into the intestine of the final hosts, when the small infected fish is devoured.

By experimentation (Hunter 1928) it was shown that the onchosphere can be seen in the body cavities of Cyclops albidus Jurine and of Cyclops prasinus Fischer 4-5 hours after ingestion. Cyclops serrulatus Fischer, Cyclops viridis (Jurine), and Cyclops fimbriatus Fischer cannot be infested. Cyclops prasinus, Cyclops albidus, Cyclops leuckarti, and Hyalella knickerbockeri are known to be the first intermediate hosts.

Proteocephalus pinguis La Rue, 1911

The adult lives in the digestive tract of Esox lucius Linnaeus and Esox reticulatus Le Sueur. Experimentally, (Hunter, 1929) Cyclops vulgaris Sars (C. viridis Jurine) and Eucyclops agilis (C. serrulatus) were infested by Hunter (1929)

but Macrocyclops annulicornis Koch (C. albidus Jurine) gave a negative result. Notropis atherinoides Raf., Notropis hudsonius (Clinton), Esox inconstans (Kirtland), and Perca flavescens Mitchill were second intermediate hosts. Notropis hudsonius and Esox inconstans gave a negative result, while Perca flavescens and Notropis atherinoides gave a positive result. The final hosts, Esox vermiculatus Le Sueur and Esox lucius were infected experimentally. Under natural conditions the infection may occur either through eating infected Cyclops, since young Esox lucius has been found to harbour adult Proteocephalus pinguis, or through eating the infected second intermediate host.

Corallobothrium parvum Larsh, 1940

This species was found in the small intestine of bullheads from the Douglas lake region of Michigan and also fron southern Illinois. The life cycle was worked out experimentally. Cyclops prasinus Fischer was the first intermediate host. The onchosphere entered the body cavity of Cyclops on the third day. And the body of Cyclops was packed with proceroids on the eighth day. The second intermediate host, Claridichthys talcatus was infested by the ingestion of the infected Cyclops. The life cycle was completed when the bullheads ingested the infected second intermediate hosts. It took 8 days from the infective eggs to procercoids in the Cyclops; 3 days from procercoids into plerocercoids in the second intermediate host; and took 4 days to transfer plerocercoids into the definitive hosts. The whole cycle took about

15 days.

Hymenolepis gracilis

The adults are found in ducks. The cysticercoids were found in Cyclops. Hymenolepis collaris (Batsch) and Hymenolepis coronula have not been seen in nature in adult stage. But the cysticercoids were found along with Hymenolepis gracilis in Cyclops (Villers-sur-Mer 1930). The duck gets the parasites from eating the snails which probably contain the infected Cyclops.

Drepanidotaenia lanceolata (Bloch 1782)

The adults live in the goose, Anser anser domesticus. The cysticercoid was found by Daday (1900) in Diaptomus spinosus. The life cycle was studied experimentally by Ruszkowski (1930). Cyclops strenuus Fischer, Cyclops insignis Claus, Cyclops viridis Fischer, Cyclops fuscus Schmeil and Diaptomus gracilis Sars were used as first intermediate hosts. Hundred per cent of Cyclops strenuus were infected. Even the copepodid stage could be infected. Diaptomus gracilis and Cyclops insignis ingested the larvae but became infected only in small protion. Cyclops viridis and Cyclops fuscus could not be infected.

Bothriocephalus rarus Thomas 1937

The eggs of Bothriocephalus rarus pass in the feces of adult newts and hatch in 3-8 days. During 3 days, the coracidia are ingested by several species of copepods. In experiments, Mesocyclops obsoletus Sars (C. leuckarti Claus),

Cyclops vulgaris Sars (C. viridis (Jurine)), and Macrocyclops annulicornis Koch (C. albidus Jurine) can be infected by Bothriocephalus rarus larvae, which take 30 minutes to come into the body cavity. After about 10-14 days, the procercoid is ready to infect the second host, a larval or adult newt, Triturus viridescens. An adult newt may either get the infection directly from eating infected cyclops or from eating an infected larval newt.

Triaenophorus robustus Olsson 1892

The larvae first undergo development in the first intermediate host, a Cyclops of some species. Then they encyst in the muscle of the white fish, Leucicthys tullibee, when the Cyclops are eaten. The white fish are in turn eaten by Esox lucius, so the larvae get into the intestine of the final host.

Triaenophorus crassus Forel

The infection of the first intermediate host, Cyclops bicuspidatus Claus in Lesser Slave Lake, Alberta, reaches the peak at the end of May (Miller 1945). The second intermediate host, Leucichthys species, is necessary. Without it, the life cycle can not be completed. When procercoids get into the body of Leucichthys, they penetrate the pyloric caeca, cross the body cavity and enter the flesh. Plerocercoids encyst in flesh in July. The final host, Esox lucius Linnaeus, gets the parasite by eating the infected second intermediate host.

Triaenophorus stizostedionis Miller 1945

The adult is in the intestine of the pike-perch, Stizostedion vitreum (Mitchill). Cyclops bicuspidatus Claus is the first intermediate host. The procercoid develops in Cyclops bicuspidatus about 10 days to 2 weeks. The second intermediate host, trout-perch is infected by ingesting the infected Cyclops. The plerocercoids encyst on the visceral and parietal peritoneum. When a pike-perch eats an infected trout-perch Percopsis omiscomaycus (Walbaum), it becomes infected. Under natural conditions, Cyclops bicuspidatus carrying mature procercoids of Triaenophorus stizostedionis are present from the middle to the end of June in Lesser Slave Lake. By experiment, Cyclops bicuspidatus is easily infected with coracidia of Triaenophorus stizostedionis. The coracidia enter the gut of Cyclops within one hour, and reach the body cavity after only a few hours.

Triaenophorus nodulosus (Pallas)

The eggs of Triaenophorus nodulosus are scattered in the water in early June, in Lesser Slave Lake (Miller 1945). The eggs are hatched within few hours. About 1-2 days the coracidia are eaten by Cyclops bicuspidatus Claus which is the first intermediate host, while in Europe Cyclops strenuus Fischer is the first intermediate host. The procercoids are fully formed from 10 days to 2 weeks, and ready for the next host, burbot fry, Lota lota maculosa (Le Sueur). In Europe, there are more than 30 species of fresh water fishes which serve as

second intermediate host. The procercoids penetrate through the gut wall of burbot into the body cavity and at last reach the liver. At the end of the summer they are ready to infect the final host, the pike, *Esox lucius*.

In experiments by Michajlow (1932), *Diaptomus amblyodon*, *Diaptomus castor* (Jurine), and *Cyclops viridis* (Jurine) could not be infected. *Cyclops leuckarti* Claus only 1% infected. *Cyclops serrulatus* Fischer, 2.5%; *Cyclops albidus* Jurine, 3%; and *Cyclops bicuspidatus* Claus, 66% were infected. *Diaptomus gracilis* Sars 25% were infected, and female is more often to be infected than male. Forty per cent of females were infected, and only 10% of males . Both the feamle and male of *Cyclops strenuus* Fischer were infected equally.

Diphyllobothrium erinacei (Rudolphi 1819)

The adult is found in cat, dog, and man. The eggs are hatched after about 18 days in water. The coracidium is ingested by Cyclops species and develops into a procercoid. The final hosts, cat and dog, get the parasite by eating the infected second intermediate hosts, frog, toad, and snake. But man may get the parasite by drinking water which contains infected Cyclops.

Diphyllobothrium ranarum Meggitt, 1925

This tapeworm is found in cat, dog, especially cat. The infection is frequent among frogs in Batavia, Java (De Hartogh, 1932). It is occasionally found in monkeys by Bonne (De Hartogh) and in pigs by Meyer (De Hartogh). Spargana also are found in natural infection of man and monkeys in Batavia. A local Cyclops acts as the first intermediate host. It is easy to infect Cyclops experimentally, but it is difficult to infect frogs or toads with infected Cyclops. In experiments by Can Koen Han (1941), the procercoid larvae in the Cyclops developed a cercomer in 4-9 days. Mice could be infected experimentally by feeding them infected tadpoles. Monkeys could be infected experimentally by feeding them Cyclops containing fully developed procercoids. Man also may get the infection when swallowing the infected Cyclops.

3. NEMATODA

Dracunculus medinensis Linnaeus 1758

This worm is a common parasite of man in tropical Africa, Arabia, the Dutch East Indies, and India. It is a parasite of domesticated and wild animals including the dog, cat, leopard, cattle, sheep, etc. of the Old World. The female worm produces thousands of larvae which are ingested by the Cyclops. Shortly after ingestion, the larvae penetrate the wall of the stomach and pass into the body cavity. Within the body cavity of Cyclops the larvae undergo two molts, become a cylindrical shape, and after about 4-6 weeks become infective for man. Infection results from drinking water containing infected Cyclops.

The most important Cyclops which harbour the larvae of the guinea worm are *Cyclops coronatus* Claus, *Cyclops leuckarti* Claus, *Cyclops quadrecornis*, *Cyclops viridis* (Jurine), *Cyclops prasinus* Fischer, *Cyclops bicuspidatus* Claus, *Cyclops strenuus* Fischer, and *Cyclops hyalinus*. *Cyclops leuckarti* and *Cyclops hyalinus* have been used in laboratory infection..

The periods required for larvae to develop within the bodies of Cyclops have been studied by several investigators. Fedtschenko (1871) indicated the larvae of *Dracunculus medinensis* completed the metamorphosis on the twelfth day. Manson (1893) in London found ecdysis was postponed until the sixth week. Leiper (1907) in Africa, found the metamorphosis completed at fifth week. Fairley and Liston (1924) in India

found the metamorphosis completed on fifteenth day. Issajev (1934) in Russia found the metamorphosis was completed about thirteen days after the infection. Moorthy (1938) indicated thoroughly the changes of larvae inside the bodies of Cyclops. The larvae penetrated into the body cavity of Cyclops about 1-6 hours after they were swallowed. They underwent the first molt between the fifth and seventh day and the second molt between the eighth and twelfth day in hot weather (90-120 F). The larvae increased in size about a week after they had shed the exuviae of the second molt. He also indicated that infection is more common and heavier in *Cyclops leuckarti* than in *Cyclops hyalinus*, and more common and heavier in female of both species than in the male. Immature forms of both species of Cyclops were infected more easily than the adults. Usually only a single larva infects Cyclops under natural condition, but under laboratory conditions it is possible for 15-20 larvae to infect one Cyclops. Moorthy and Sweet (1839) did the further experimental work with the infection of Cyclops, using *Cyclops leuckarti* and *Cyclops hyalinus*, and found that Cyclops were infected in about 24-48 hours. The larvae remained in the body cavity of Cyclops about 3 weeks, underwent two molts, then became infective. The activity of larvae also could be increased by stimulating them with 2% of HCl or fresh bile.

Camallanus sweeti Moorthy 1937

Moorthy found *Cyclops leuckarti* Claus in South India were infected with *Camallanus sweeti* larvae under natural condi-

tions. Cyclops leuckarti is the first intermediate host. The fresh water fish, Barbus puckelli or Lepidocephalichthys thermalis and Gambusia are the second intermediate hosts. A fresh water fish Ophicephalus gachua Ham is the definitive host. The larvae pass out with feces of the fish, Ophicephalus gachua, and are eaten by possibly adult female Cyclops leuckarti. About 2-3 hours after infection, they reach the body cavity of Cyclops. After about 24-86 hours, they undergo first molt; after 5-7 days during hot weather or 8-12 days in cooler weather they undergo second molt. When Barbus puckelli Day or Lepidocephalichthys thermalis ingest the infected Cyclops, which are killed by the degestive juice, the larvae are set free and activated. The final host acquires the parasites by feeding on the infected fresh water fish.

Under experimental conditions, Moorthy (1938) indicated that only the females of Cyclops leuckarti bearing ovisacs are infected, and they are more easily infected than those of hyalinus. Each Cyclops may contain 12-15 larvae. The larvae reach the body cavity about 4-8 hours after infection. The first molt begins at about 24-36 hours. The second molt takes place between the 5th and 7th day during hot weather.

Procamallanus fulvidraconis Li 1935

Under natural conditions, about 30% of the old Pseudobagrus fulvidraco are infected in Peiping, China. Larvae were experimentally found to infect Cyclops species. Cyclops

serrulatus Fischer, *Cyclops vicinus* Uljanin and *Cyclops magnus* Marsh were used as first intermediate hosts. *Cyclops serrulatus* showed the highest percentage of infection, *Cyclops vicinus* medium, and *Cyclops magnus* showed lowest infective percentage. But it showed the intermediate host was effected in a passive way. The larvae penetrated the intestine of Cyclops about 3 hours after ingestion. On the 8th or 9th day, the first molt took place. Then the larvae became coiled up and remained quiescent in the body cavity of Cyclops until the host died.

Spiroxys contortus (Rudolphi)

Both adult and encysted larvae are found in the stomach of several species of turtles. In North America nine species of turtles serve as definitive hosts. These are: *Chrysemys bellii marginata* (Agassiz), *Emys blandingii* (Holbrook), *Graptemys geographica* (Le Sueur), *Sternotherus odoratus* (Latreille), *Kinosternum subrubrum* (Lacepede), *Chelydra serpentina* (Linnaeus), *Pseudemys elegans* (Wiend), *Pseudemys texana* Baur, and *Emys orbicularis* (Linn.). The experimental final hosts are *Terrapene carolina carolina* (Linnaeus) and *Terrapene carolina ornata*.

Cyclops leuckarti Claus, *Cyclops albidus* Jurine, *Cyclops serrulatus* Fischer, and *Cyclops brevispinosus* Herrick are the first intermediate hosts. Mud minnows, *Umbra limi*, bullheads, *Ameiurus nebulosus*, tadpoles and adults of *Rana clamitans*, larvae and adults of newts, *Triturus viridescens*, and dragonfly nymphs are natural second hosts. Tadpoles and *Ameiurus nebulosus* can be

infected experimentally. Turtles, _Terrapene carolina carolina_ and _Terrapene carolina ornata_ can be infected by feeding Cyclops with third stage infective larvae or by feeding _Umbra limi_ with encysted larvae.

Hedrick (1935) used _Cyclops leuckarti_, _Cyclops albidus_, _Cyclops serrulatus_, _Cyclops brevispinosus_ and _Cyclops bicuspidatus_ Claus as first intermediate hosts. _Cyclops bicuspidatus_ ingests the larvae but inhibits their growth. The larvae develop well in _Cyclops leuckarti_. A large number of larvae developed well in the body cavity of a single _Cyclops albidus_.

A list of Copepoda which serve as intermediate hosts of helminths, as given by Hall (1929), is shown in Table 1.

TABLE 1

A list of Copepoda which serve as intermediate hosts of helminths (Hall 1929).

Family	Trematode	Primary host	Group	Secondary host
Hemiuridae	Hemiurus appendiculatus	Perca fluviatilis Coregonus oxyrrhynchus Lampetra fluviatilis Lota lota Esox lucius Salmo fario Clupea finta Caspialosa kessleri Osmerus mordax	fish	Acartia clausa
	Derogenes varicus	Coregonus oxyrrhynchus Thymallus thymallus Gadus callarias Urophycis tenuis Anarrhichas lupus Hippoglossus hippoglossus Salmo salar	fish	Acartia sp.
Brachycoeliidae (uncertain)	Distomum sp. Herrick	?	?	Cyclops tenuicornis

TABLE 1

Family	Cestode	Primary host	Group	Secondary host
Hymenolepididae	*Hymenolepis anatina*	*Anas spp.* Swan *Dafila acuta*	Anseriformes	*Cyclops vernalis* *Diaptomus alluaudi* *Diaptomus spinosus*
	Hymenolepis brachycephala	*Pavoncella pugnax* *Totanus pugnax* *Tringa sp.*	Charadriiformes	*Cyclops fimbriatus* *Cyclops crassicornis*
	Hymenolepis collaris	*Anas spp.* *Anser spp.* *Aythya fuligula* *Dafila acuta*	Anseriformes	*Diaptomus coeruleus* *Cyclops viridis* *Cyclops agilis* *Cyclops lucidulus* *Cyclops serrulatus* *Cyclops vernalis*
	Hymenolepis gracilis	Duck Goose Wild water fowl Green pigeon	Anseriformes Columbiformes	*Diaptomus coeruleus* *Diaptomus spinosus* *Cyclops viridis*
	Hymenolepis tenuirostris	Duck Goose *Merganser spp.* *Aythya spp.*	Anseriformes	*Cyclops agilis* *Cyclops pulchellus* *Cyclops serrulatus* *Cyclops bicuspidatus* *Diaptomus coeruleus*
	Hymenolepis microsoma	*Nyroca spp.* *Oedmia spp.*	Anseriformes	*Cyclops agilis*

TABLE 1

Family	Cestode	Primary host	Group	Secondary host
Hymenolepididae	*Hymenolepis microsoma* (continued)	*Larus spp.*	Lariformes	*Cyclops serrulatus*
	Hymenolepis setigera	Goose Wild water fowl	Anseriformes	*Cyclops brevicaudatus* *Cyclops strenuus* *Diaptomus coeruleus*
	Hymenolepis fasciculata	Goose Wild water fowl	Anseriformes	*Cyclops agilis* *Cyclops viridis* *Cyclops serrulatus* *Diaptomus coeruleus*
	Drepanidotaenia lanceolata	Goose Duck Wild water fowl	Anseriformes	*Diaptomus spinosus* *Cyclops serratus*
	Dicranotaenia dubia	?	?	*Diaptomus alluaudi*
	Echinocotyle polyacantha	?	?	*Diaptomus asiaticus*
	Echinocotyle mrazeki	*Pyromelana franciscana*	Passeriformes	*Boeckella braziliensis*
	Echinocotyle linstowi	?	?	*Diaptomus asiaticus* *Diaptomus spinosus*

TABLE 1

Family	Cestode	Primary host	Group	Secondary host
Hymenolepididae	*Fimbriaria fasciolaris*	Duck		*Diaptomus vulgaris*
		Goose	Anseriformes	
		Wild water fowl		
		Chicken ?	Galliformes	*Cyclops* sp.
Proteocephalidae	*Proteocephalus torulosus*	*Aspius* spp.		*Cyclops serrulatus*
		Leuciscus spp.		*Cyclops brevicaudatus*
		Lota vulgaris	fish	*Cyclops agilis*
		Idus melanotus		*Cyclops strenuus*
		Abramis brama		*Diaptomus castor*
		Alburnus lucidus		
		Coregonus fera		
	Proteocephalus filicollis	*Gasterosteus aculeatus*	fish	*Cyclops varius*
	Proteocephalus longicollis	*Coregonus albula*	fish	*Cyclops strenuus*
				Cyclops serrulatus
	Proteocephalus percae	*Gasterosteus aculeatus*	fish	*Cyclops strenuus*
				Cyclops serrulatus
				Cyclops oithonoides

TABLE 1

Family	Cestode	Primary host	Group	Secondary host
Proteocephalidae	Proteocephalus amboplitis	Ambloplites rupestris Micropterus dolomieu	fish	Cyclops leuckartii Cyclops prasinus Cyclops albidus
	Ichthyotaenia sp. Fuhrmann 1926	?	?	Cyclops strenuus
	Corallobothrium giganteum	Ameiurus melas Leptops olivarius Ictalurus punctatus	fish	Cyclops serrulatus Cyclops prasinus
	Corallobothrium fimbriatum	Ameiurus melas Leptops olivarius Ictalurus punctatus	fish	Cyclops serrulatus Cyclops bicuspidatus
Diphyllobothriidae	Schistocephalus solidus	Duck Wild water fowl	Anseriformes	Cyclops serrulatus Cyclops bicuspidatus
	Diphyllobothrium latum	Dog Cat Fox Wild carnivores Man	Carnivores Primate	Diaptomus oregonensis Diaptomus gracilis Diaptomus graciloides Cyclops strenuus Cyclops brevispinosus Cyclops prasinus Cyclops robustus

TABLE 1

Family	Cestode	Primary host	Group	Secondary host
Diphyllobothriidae	*Diphyllobothrium mansoni*	Dog Cat	Carnivores	*Cyclops leuckartii*
	Bothriocephalus cuspidatus	*Stizostedion vitreum* *Hiodon tergisus* *Percina caprodes*	fish	*Cyclops prasinus* *Cyclops serrulatus* *Cyclops leuckartii* *Cyclops bicuspidatus* *Cyclops brevispinosus*
	Abothrium crassum	*Salmo* spp. *Coregonus* spp. *Thymallus thymallus*	fish	*Cyclops strenuus* *Cyclops serrulatus*
	Abothrium infundibuliformis	*Trutta lacustris*	fish	*Cyclops strenuus* *Cyclops serrulatus*
	Triaenophorus nodulosus	*Salmo* spp. *Coregonus* spp. *Trutta* spp. *Thymallus thymallus* *Esox lucius*	fish	*Cyclops strenuus* *Cyclops fimbriatus*
Rhynchobothriidae	Cysticercoid of Mrazek 1896;13	?	?	*Diaptomus* sp.
	Cysticercus gruberi	?	?	*Cyclops brevicaudatus* *Cyclops agilis* *Cyclops strenuus*

TABLE 1

Family	Cestode	Primary host	Group	Secondary host
Rhynchobothriidae	Cysticercoid of Rossiter 1893	?	?	*Cyclops agilis*
	Cysticercoid quadricurvatus	?	?	*Cyclops agilis*
	Cysticercus sp. of Lueche 1910	?	?	*Cyclops serrulatus*
	Cercocystis dendrocercus	?	?	*Diaptomus* sp.
	Plerocercus africanus	?	?	*Diaptomus africanus*
	Taenia zichyi	?	?	*Diaptomus asiaticus*

TABLE 1

Family	Nematode	Primary host	Group	Secondary sost
Cucullanidae	Cucullanus elegans	Silurns glanis Aspius rapax Esox lucius Gadus lota Perca fluviatilis Anquillula vulgaris	fish	Cyclops gradricornis
Camallanidae	Camallanus lacustris	Perca fluviatilis Lucioperca sandra Acerina cernua Aspro zingel Leuciscus rutilus Aspius rapax Barbus fluviatilis Tinca vulgaris Esox lucius Lota vulgaris Salmo salar Trutta trutta Salvelinus fontinalis Coregonus oxyrrhynchus Osmerus eperlanus Silurus glanis Anguillula vulgaris	fish	Cyclops sp.

TABLE 1

Family	Nematode	Primary host	Group	Secondary host
Camallanidae	*Camallanus microcephalus*	*Emys lutaria*	Reptile	? *Cyclops* sp.
Dracunculidae	*Dracunculus medinensis*	Man	Primate	*Cyclops coronatus*
		Dog		*Cyclops leuckartii*
		Leopard	Carnivores	*Cyclops quadricornis*
		Horse		*Cyclops viridis*
		Cattle		*Cyclops prasinus*
		Sheep		*Cyclops bicuspidatus*
		Goat	Ungulates	*Cyclops strenuus*
		Gazella bennetti		
	Dracunculus sp. ?	Indian cobra	Reptile	*Cyclops* sp.
	Dracunculus globocephalus	*Chelydra serpentina*	Reptile	*Cyclops bicuspidatus*
	Philometra sanguineus	*Carassius vulgaris*		*Cyclops* sp.
		Abramis vimba		*Diaptomus* sp.
		Galaxias scriba		
		Leuciscus rutilus	fish	
		Osmerus eperlani		
		Cottus gobio		

TABLE 2

A list of the intermediate hosts of helmenths that have been found under natural conditions or have been experimentally determined since 1929.

Family	Trematode	Primary host	Group	Secondary host
Hemiuridae	Cercaria sphaerula Thomas 1932	Helisoma trivolvis	mollusca	Cyclops vulgaris Schmeil
	Lecithaster confusus Odhner 1905	Marine fish	fish	Acartia clausi Giesb.
	Halipegus eccentricus Thomas 1939	Frog	amphibian	Cyclops vulgaris Schmeil Cyclops obsoletus Sars
	Halipegus ovocaudatus Vulpian 1859	Frog	amphibian	Cyclops sp.
	Halipegus occidualis Stafford 1905	Rana clamitans	amphibian	Cyclops vernalis Fisher Cyclops serrulatus Claus

TABLE 2

Family	Cestode	Primery host	Group	Secondary host
Diphyllobothriidae	*Triaenophorus crassus* Forel	*Esox lucius*	fish	*Cyclops bicuspidatus* Claus *Diaptomus ashlandi*
	Triaenophorus stizostedionis Miller 1945	*Stizostedion vitreum*	fish	*Cyclops bicuspidatus* Claus
	Triaenophorus nodulosus Pallas	*Esox lucius*	fish	*Cyclops bicuspidatus* Claus
	Schistocephalus solidus (O. F. Muller)	Duck	Anseriformes	*Cyclops viridis* (Jurine)
	Triaenophorus robustus Olsson 1892	*Esox lucius*	fish	*Cyclops* sp.
Hymenolepididae	*Drepanidotaenia lanceolata* (Bloch 1782)	Goose Domestic duck Swan Barbary duck	Anseriformes	*Diaptomus gracilis* Sars *Cyclops insignis* *Cyclops strenuus* Fischer
	Bothriocephalus rarus	*Triturus viridescens*	reptile	*Cyclops obsoletus* Sars *Cyclops vulgaris* Schmeil *Cyclops annulicornis* Sars
Proteocephalidae	*Ophiotaenia perspicua* LaRue	*Natrix rhombifera*	reptile	*Cyclops viridis* (Jurine) *Cyclops varicans* Sars
	Ophiotaenia saphena Osler 1931	*Rana clamitans*	amphibian	*Cyclops vulgaris* Schmeil
	Crepidobothrium testudo (Magath 1924)	Turtle	reptile	*Cyclops leuckarti* Claus

TABLE 2

Family	Cestode	Primary host	Group	Secondary host
Proteocephalidae	*Corallobothrium parvum* Larsh 1940	*Ameiurus nebulosus*	fish	*Cyclops* sp.
	Proteocephalus pinguis La Rue 1911	*Esox lucius* *Esox reticulatus*	fish	*Cyclops vulgaris* Schmeil *Cyclops agilis* Koch
Diphyllobothriidae	*Diphyllobothrium erinacei* (Rudolphi 1819)	Man Monkey Cat Pig Domestic fowls Frog, etc.	primate carnivores anseriformes amphibia	*Cyclops* sp.
	Diphyllobothrium mansonoides Mueller 1935	Cat Bobcat Dog	carnivore	*Cyclops leuckarti* Claus *Cyclops viridis* (Jurine) *Cyclops bicuspidatus* Claus
	Diphyllobothrium ranarum Meggitt 1926	Dog Cat	carnivores	*Cyclops* sp.
Dracunculidae	*Dracunculus medinensis* Linnaeus 1758	Man Dog Leopard Horse Cattle Sheep	primate carnivores ungulates	*Cyclops leuckarti* Claus *Cyclops hyalinus* Rehberg *Cyclops brevispinosus* Marsh
	Dracunculus ophidensis Brackett 1935	*Thamnophis sirtalis*	reptile	*Cyclops viridis* (Jurine)

TABLE 2

Family	Nematode	Primary host	Group	Secondary host
Dracunculidae	*Philometra nodulosa* Thomas 1929	*Catostomus commersonii*		*Cyclops brevispinosus* Marsh
	Dracunculus oesophageus (Polonio 1859)	*Tropidonotus natrix persa*	reptile	*Cyclops fuscus* (Jurine)
Spiruridae	*Spiroxys contortus* (Rudolphi)	*Chrysemys bellii marginata* *Emys blandingii* *Graptemys geographica* *Sternotherus odoratus* *Kinosternum subrubrum* *Chelydra serpentina* *Pserdemys texana* *Pseudemys elegans* *Emys orbicularis* *Terrapene carolina carolina* *Terrapene carolina ornata*	reptile	*Cyclops leuckarti* Claus *Cyclops albidus* Jurine *Cyclops serrulatus* Claus *Cyclops brevispinosus* Marsh
Camallanidae	*Camallanus sweeti* (Moorthy 1937)	*Ophicephalus gachua*	fish	*Cyclops leuckarti* Claus
	Procamallanus fulvidraconis Li 1935	*Pseudobagrus fulvidraco*	fish	*Cyclops serrulatus* Claus *Cyclops vicinus* Uljanin *Cyclops magnus* Marsh
	Camallanus lacustris Zoega 1776	Species of fish		*Cyclops* sp.
Gnathostomidae	*Gnathostoma hispidium* Fedeschenko 1872	Cattle Hog Man	 ungulate primate	*Cyclops* sp.

TABLE 2

Family	Nematode	Primary host	Group	Secondary host
Gnathostomidae	*Gnathostoma spinigerum* Owen 1836	Cat	carnivore	*Cyclops* sp.

In Table 3 both Hall's (1929) list and my additional data are combined in a list of all Copepoda known to serve as intermediate hosts of helminths.

TABLE 3

List of Copepoda and the helminths they carry.

Copepoda (host species)	Trematode	Cestode	Nematode
Cyclops serrulatus Claus	*Halipegus occidualis*	*Cysticercus* sp. of Lueche *Abothrium infundibulifoumis* *Abothrium crassum* *Bothriocephalus cuspidatus* *Schistocephalus solidus* *Corallobothrium fimbriatum* *Corallobothrium giganteum* *Proteocephalus percae* *Proteocephalus longicollis* *Proteocephalus torulosus* *Hymenolepis fasciculata* *Hymenolepis microsoma* *Hymenolepis tenuirostris* *Hymenolepis collaris*	*Spiroxys contortus* *Procamallanus fulvidraconis*

TABLE 3

Copepoda (host species)	Trematode	Cestode	Nematode
Cyclops strenuus Fischer		*Cysticercus gruberi*	*Dracunculus medinensis*
		Abothrium infundibuliformis	
		Abothrium crassum	
		Triaenophorus nodulosus	
		Diphyllobothrium latum	
		Ichthyotaenia sp.	
		Proteocephalus percae	
		Proteocephalus longicollis	
		Proteocephalus torulosus	
		Hymenolepis setigera	
		Drepanidotaenia lanceolata	

TABLE 3

Copepoda (host species)	Trematode	Cestode	Nematode
Cyclops leuckarti Claus		*Bothriocephalus cuspidatus* *Diphyllobothrium mansoni* *Proteocephalus ambloplitis* *Crepidobothrium testudo* *Diphyllobothrium mansonoides*	*Dracunculus medinensis* *Spiroxys contortus* *Camallanus sweeti*
Cyclops bicuspidatus Claus		*Bothriocephalus cuspidatus* *Diphyllobothrium mansonoides* *Schistocephalus solidus* *Corallobothrium fimbriatum* *Hymenolepis tenuirostris* *Triaenophorus crassus* *Triaenophorus stizostedionis* *Triaenophorus nodulosus*	*Dracunculus medinensis* *Dracunculus globocephalus*

TABLE 3

Copepoda (host species)	Trematode	Cestode	Nematode
Cyclops agilis Koch		*Cysticercoid quadricurvatus* *Cysticercus gruberi* Cysticercoid of Rossiter *Proteocephalus torulosus* *Hymenolepis microsoma* *Hymenolepis tenuirostris* *Hymenolepis collaris* *Hymenolepis fasciculata* *Proteocephalus pinguis*	
Cyclops brevicaudatus		*Cysticercus gruberi* *Proteocephalus torulosus* *Hymenolepis setigera*	

TABLE 3

Copepoda (host species)	Trematode	Cestode	Nematode
Cyclops prasinus		*Diphyllobothrium latum* *Corallobothrium giganteum* *Proteocephalus ambloplitis* *Bothriocephalus cuspidatus*	*Dracunculus medinensis*
Cyclops vernalis Fischer	*Halipegus occidualis*	*Hymenolepis anatina* *Hymenolepis collaris*	
Cyclops viridis (Jurine)		*Hymenolepis fasciculata* *Hymenolepis collaris* *Ophiotaenia perspicua* *Diphyllobothrium mansonoides* *Schistocephalus solidus* *Hymenolepis gracilis*	*Dracunculus medinensis* *Dracunculus ophidensis*
Cyclops albidus Jurine		*Proteocephalus ambloplitis*	*Spiroxys contortus*

TABLE 3

Copepoda (host species)		Cestode	Nematode
Cyclops vulgaris Schmeil	Cercaria sphaerula Halipegus eccentricus	Ophiotaenia saphena Proteocephalus pinguis Bothriocephalus rarus	
Cyclops brevispinosus Marsh		Bothriocephalus cuspidatus Diphyllobothrium latum	Dracunculus medinensis Philometra nodulosa Spiroxys contortus
Cyclops fimbriatus Fischer		Hymenolepis brachycephala Triaenophorus nodulosus	
Cyclops quadricornis			Cucullanus elegans Dracunculus medinensis
Cyclops spp.	Halipegus ovocaudatus	Corallobothrium parvum Diphyllobothrium erinacei Diphyllobothrium ranarum Triaenophorus robustus	Camallanus lacustris Camallanus microcephalus Dracunculus sp. Philometra sunguineus Gnathostoma hispidium Gnathostoma spinigerum

TABLE 3

Copepoda (host species)	Trematode	Cestode	Nematode
Cyclops coronatus			Dracunculus medinensis
Cyclops crassicornis Sars		Hymenolepis brachycephala	
Cyclops vicinus Uljanin			Procamallanus fulvidraconis
Cyclops oithonoides		Proteocephalus percae	
Cyclops varicans Sars		Ophiotaenia perspicua	
Cyclops insignis		Drepanidotaenia lanceolata	
Cyclops annulicornis Sars		Bothriocephalus rarus	
Cyclops lucidulus		Hymenolepis collaris	
Cyclops pulchellus		Hymenolepis tenuirostris	
Cyclops robustus		Diphyllobothrium latum	
Cyclops tenuicornis	Distomus sp. Herrick		
Cyclops obsoletus Sars	Halipegus eccentricus	Bothriocephalus rarus	
Cyclops hyalinus Rehberg.			Dracunculus medinensis
Cyclops magnus Marsh			Procamallanus fulvidraconis
Cyclops fuscus (Jurine)			Dracunculus oesophageus
		Drepanidotaenia lanceolata	

TABLE 3

Copepoda (host species)	Trematode	Cestode	Nematode
Diaptomus gracilis Sars		*Diphyllobothrium latum*	
		Hymenolepis collaris	
		Hymenolepis tenuirostris	
		Drepanidotaenia lanceolata	
Diaptomus spinosus		*Echinocotyle linstowi*	
		Drepanidotaenia lanceolata	
Diaptomus alluaudi		*Hymenolepis anatina*	
		Hymenolepis gracilis	
		Dicranotaenia dubia	
Diaptomus coeruleus		*Hymenolepis setigera*	
		Hymenolepis tenuirostris	
		Hymenolepis gracilis	
		Hymenolepis collaris	
Diaptomus africanus		*Plerocercus africanus*	
Diaptomus vulgaris		*Fimbriaria fasciolaris*	
		Diphyllobothrium latum	
Diaptomus graciloides		*Diphyllobothrium latum*	
Diaptomus silicoides		*Diphyllobothrium latum*	
Diaptomus castor		*Proteocephalus torulosus*	

TABLE 3

Copepoda (host species)	Trematode	Cestode	Nematode
Diaptomus oregonensis		*Diphyllobothrium latum*	
Diaptomus asiaticus		*Echinocotyle polyacantha* *Echinocotyle linstowi* *Taenia zichyi*	
Diaptomus ashlandi		*Triaenophorus crassus*	
Diaptomus sp.			*Philometra sanguineus* *Cercocystis dendrocercus*
Acartia clausi	*Hemiurus appendiculatus* *Lecithaster confusus*		
Acartia sp.	*Derogenus varicus*		

Up to the present time more than 15 species of Copepoda are known to serve as first intermediate hosts of nematodes. The larvae mostly molt twice in the body cavity of the copepod, and there they develop into the infective stage. The final hosts become infected through directly swallowing the infected cyclops or through eating the infected second intermediate host.

More than 11 species of Copepoda serve as second intermediate hosts of trematodes. The larvae develop into metacercariae inside the body of the copepod. Final hosts acquire the parasites by eating the infected cyclops.

More than 33 species of Copepoda are the first intermediate hosts of cestodes. The larvae transform to procercoids inside the copepod's body. Final hosts get the infection by eating either the infected second intermediate host or the infected copepods.

TABLE 4

Hosts using copepods and copepods serving as intermediate hosts reported since 1929.

	Trematode	Cestode	Nematode
Hosts using copepods	5 species	15 species	11 species
Copepods serving as intermediate hosts	5 species	12 species	9 species

Hosts using copepods and copepods serving as intermediate hosts, according to Hall (1929).

Trematode	Cestode	Nematode	
3 species	37 species	7 species	Hosts using copepods
2 species	29 species	8 species	Copepods serving as intermediate hosts

V. Description of two species of freshwater copepods from Borneo

The following two species, Mesocyclops leuckarti and Microcyclops sp., here in described are from Dr. Humes' collection, the former from Selor, and the latter from Tarakan, Borneo (approximate location 3° N. lat. and 117° E. long.).

A. Mesocyclops leuckarti

Female.-Proportional lengths of the anterior and posterior regions of the body are as 757 to 371, while the proportion of the cephalic segment to the whole body is as 29 to 81. The width of thorax is about 1/3 the total length. The body measurements are shown in Table 5.

TABLE 5

Body measurements of Mesocyclops leuckarti, female.

Body length		1.256 mm.	(1.115---1.372 mm.)
Body width		0.427 mm.	(o.414---0.557 mm.)
Length of egg sac		0.475 mm.	(0.357---o.614 mm.)
Length of rami		86.9µ	(71.5----100.1µ)
Length of furcal setae	1	82.2µ	(71.5----100.1µ)
	2	375.3µ	(314.6---443.3µ)
	3	o.507 mm.	(0.457---0.572 mm.)
	4	241.9µ	(185.9---286.0µ)

The 16th and 17th segments of the first antennae have conspicuous hyaline plates, that on segment 17 broader and showing a distinct notch. The plate on segment 16 is narrower and the margin is very finely serrated (Fig. 1). The proportional lengths of the segments are as follows:

Segment	1	2	3	4	5	6
	115.2μ	22.4μ	12.8μ	41.6μ	32μ	16μ

7	8	9	10	11	12
48μ	25.6μ	25.6μ	25.6μ	25.6μ	28.8μ

13	14	15	16	17
28.8μ	25.6μ	41.6μ	70.4μ	57.6μ

The posterior antennae are slender, each with 4 podomeres (Fig. 2). The proportional lengths are:

Segment	1	2	3	4
	80μ	70.4μ	67.3μ	80μ

The mandible has 3 setae at the outer proximal part, one short and 2 unusually long (Fig. 3).

The rest of the morth parts are of the types figured by previous authors (Gurney 1931).

The first pair of legs (Fig. 8) shows the first basal segment without an inner seta. The exopodite of podomeres 2 and 3 are fringed along the outer margin with hairs while that of segment 1 is fringed with spinules. Each podomere of both endopodite and exopodite bears a row of spinules near the articulation of the podomeres.

The second pair of legs (Fig. 9) shows the inner margin of the first podomere of the exopodite and podomeres 1, 2, and 3 of the endopodite fringed with hairs. The other margin of all three podomeres of the exopodite are fringed with spinules. Each podomere of both endopodite and exopodite bears a row of spinules across the surface near the distal margin.

The third pair of legs is like the second pair, only smaller (Fig. 10).

In the fourth pair of legs (Fig. 11) the first basal segment bears a row of spinules along the proximal margin and a short row on the articulation between the distal margin and the first podomeres of both exopodite and endopodite. Podomeres 1 and 2 of both exopodite and endopodite bear a row of spinules bear the distal margin. Podomere 3 of the endopodite is elongated, measuring 76.8 x 28.8μ . The inner terminal spine of the endopodite is 70μ in length and the outer 60μ. Detailed measurements of the first four pairs of legs are shown in Table 6.

TABLE 6

Leg measurements of *Mesocyclops leuckarti*, female.

Legs	Exopodite				Endopodite			
	Podomere				Podomere			
	1	2	3	total length	1	2	3	total length
1st	51.2	30.1	39.0	120.3μ	41.6	37.1	63.3	142.0 μ
2nd	64.0	46.7	71.7	182.4μ	47.3	48.0	79.3	174.6 μ
3rd	60.8	46.1	75.5	182.4μ	48.0	48.6	88.9	185.5μ
4th	45.4	35.2	62.7	143.3μ	44.8	44.8	76.1	165.7μ

In the fifth pair of legs the spine of the terminal podomere is shorter than the terminal seta (Fig. 12).

The furcal rami (Fig. 14) are more than twice as long as wide, and about 13% of body length. The inner margins are naked. The lateral seta is inserted 1/3 of the length from the distal end. There is a row of spinules around the distal margin of the last abdominal segment.

Male-Only two males were available for study. These were prepared as whole mounts. As far as could be learned, these specimens agree with males of *Mesocyclops leuckarti*. The body measurements are given in Table 7.

TABLE 7

Body measurements of *Mesocyclops leuckarti*, male.

Body length		1.143 mm.	(0.815----1.372 mm.)
Body width		0.389 mm.	(0.286----0.529 mm.)
Length of rami		89.1μ	(57.2-----114.5μ)
Length of furcal setae	1	75.9μ	(42.9-----100.1μ)
	2	353.1μ	(243.1----414.7μ)
	3	0.491 mm.	(0.357----0.572 mm.)
	4	225.5μ	(100.1----286.0μ)

The measurements of Sarawak specimens given by Gurney (1933) correspond closely with those of the Selor specimens (Table 5). However, adult females from Selor are slightly larger in body size and the third terminal furcal seta is nearly 100 μ shorter.

TABLE 8

Adult female *Mesocyclops leuckarti* from Borneo.

Mesocyclops leuckarti from:	Sarawak	Selor
Body length	0.970 mm.	1.256 mm.
Body width	360.0μ	472.0μ
Furcal rami length	72.0μ	86.9μ
L : W	2.55	2.59
Furcal terminal setae: 1	73μ	82μ
2	370μ	375μ
3	0.600 mm.	0.507 mm.
4	235μ	242μ
Terminal podomere of endopod 4 L : W	2.86	2.66

Mesocyclops leuckarti is widely distributed. Many authors describe this species from different places in Europe, Asia, Africa, Australia, and America. So far the only description of *leuckarti* from Borneo is that by Gurney (1933) from Sarawak. It is identical with *Cyclops aspericornis* Daday.

Table 9 gives a comparison of Borneo specimens with specimens from several other tropical locations.

TABLE 9

Comparison of _Mesocyclops_ _leuckarti_, adult females, from selected locations.

_M_. _leuckarti_ from:	Furcal rami		Podomere 3 of endopod 4	
	Length	L:W	L:W	outer % of inner spine
Ceylon	81μ	2.8	3.2	100
"	72μ	2.75	3.15	105
"	80μ	2.8	2.62	77
India, Port canning	87μ	2.84	2.55	86
" , Lahore	100μ	3.6	3.15	105
" , Calcutta	88μ	3.55	3.05	108
Philippine	70μ	2.8	2.85	50
Sumatra	118μ	3.19	2.35	75
Java	157μ	3.74	3.1	109
Sarawak	72μ	2.55	2.86	103
Selor	87μ	2.5	2.66	82

A summary of the general characters of *Mesocyclops leuckarti* from Selor is as follows:

(1) Anterior antennae 17-segmented, with a hyaline plate toothed on segments 16 and 17.

(2) Swimming-legs biramous, 3-segmented.

(3) Leg 5 of 2 segments, terminal podomere with an apical seta and a long terminal inner spine.

(4) Receptaculum hammer-shaped.

(5) Leg 1 with the first basal segment without an inner seta.

(6) Spine formula 2.3.3.3.

These features appear to agree with *Mesocyclops leuckarti* (Claus 1857).

Distinctions between known species of the subgenus *Mesocyclops* and *M. leuckarti* from Borneo:

1. *M. hyalinus* (Rehb. 1880)	*M. leuckarti* from Borneo
(1) antenna 1 with lamella only half length and not emarginate.	(1) segments 16 and 17 of antenna 1 with hyaline plate.
(2) leg 1 has inner basal spine on basipod at inner distal angle.	(2) no inner basal spine on leg 1 on basipod.
2. *M. dybowskii* (Lande 1890)	
(1) tip of antenna 1 with narrow lamella, not emarginate.	(1) with broad hyaline plate and toothed.

3. *M. edax* (S. Forb. 1891)	*M. leuckarti* from Borneo
(1) leg 1 has inner basal spine.	(1) none
(2) inner terminal spine shorter than outer, with very fine barbs on leg 4 endopod.	(2) inner terminal spine longer than outer, no barbs on leg 4 endopod.
4. *M. annulatus* (Wrzski 1893)	
(1) furcal rami very elongate, 5 times as long as wide, with hairs on inner margins.	(1) furcal rami twice as long as wide, no hair on inner margins.
(2) segment 16 of antenna 1 with smooth, not toothed, membrane.	(2) segment 16 of antenna 1 with toothed hyaline membrane.
(3) inner terminal spine of leg 4 endopod shorter than outer.	(3) inner terminal spine of leg 4 endopod longer than outer.
(4) 5th leg with inner spine subterminal and longer than terminal seta.	(4) inner spine of leg 5 not longer than terminal seta.
5. *M. longisetus* (Theibaud 1914)	
(1) hairs on inner margins on furcae.	(1) no hairs.
(2) inner terminal spine of endopod of leg 4 shorter than outer.	(2) inner terminal spine of endopod of leg 4 longer than outer.

6. *M. brazilianus* Kiefer 1933	*M. leuckarti* from Borneo
(1) inner margins of furcae sparsely haired.	(1) no hairs.
(2) connecting plate of 4th leg simple, with no projection from free border.	(2) connecting plate of 4th leg with small projection.
7. *M. ellipticus* (Kiefer 1936)	
(1) some fine hairs on distal part of inner margins of furcae.	(1) no hairs.
(2) segment 17 of antenna 1 with crenate hyaline membrane.	(2) segment 17 of antenna 1 bears hyaline membrane with semilunar break in the contour.
8. *M. meridianus* (Kiefer 1926)	
(1) lateral seta on furca proximal to middle.	(1) hyaline membrane on antenna 1 toothed.
(2) hyaline plate on antenna 1 small, serrate, with small notches.	(2) leg 4 inner terminal spine of endopod a little longer than outer.
(3) on leg 4, connecting plate without projecting teeth.	

9. *M. oithonoides* (O. Sars 1863)	*M. leuckarti* from Borneo
(1) hyaline membrane on antenna 1 segments 16 and 17 smooth.	(1) hyaline membrane on antenna 1 toothed.
(2) leg 4 inner terminal spine of endopod about 5 times as long as outer.	(2) leg 4 inner terminal spine of endopod a little longer than outer.
10. *M. tenuis* (Marsh 1909)	
(1) antenna 1 of female with incompletely developed hyaline plate, not in proximal half of 17 segment.	(1) antenna 1 with completely developed hyaline plate.
(2) leg 4 inner terminal spine of endopod curved and about twice the length of outer.	(2) leg 4 inner terminal spine of endopod only a little longer than outer.
11. *M. brehmi* (Kiefer 1927)	
(1) furcal rami 4 times as long as wide; innermost terminal seta almost as long as the outer of the 2 well-developed apical setae, dorsal seta almost as long.	(1) furcal rami twice as long as wide; innermost terminal seta shorter than the outer of the 2 apical setae.

(2) hyaline plate on segments 16 and 17 of antenna 1 very small and smooth or perhaps very finely serrate.	(2) hyaline plate on antenna 1 rather broad and toothed.
(3) leg 4 connecting plate with weak unarmed prominences.	(3) leg 4 connecting plate with spine-like prominences.

12. *M. minutus* (Lowndes 1934)

(1) very small o.6- o.65 mm. for female.	(1) female 1.256 mm. in length.
(2) very short terminal setae on rami.	(2) long furcal apical setae.
(3) hyaline plate on antenna 1 smooth.	(3) hyaline plate on antenna 1 toothed.
(4) leg 4 inner terminal spine of endopod about 6 times as long as outer.	(4) leg 4 inner terminal spine only a little longer than the outer.

13. *M. inversus* (Kiefer 1936)

(1) small 0.68-0.70 mm. for female.	(1) female 1.256 mm. in length.
(2) lateral seta on rami proximal to middle of outer margin.	(2) lateral seta on rami a little distal to middle.
(3) leg 4 inner terminal spine of endopod 3/4 length of outer.	(3) leg 4 inner terminal spine of endopod a little longer than outer.

14. *M. neglectus* (O. Sars 1909)	*M. leuckarti* from Borneo
(1) antenna 1 with no conspicuous hyaline membrane on segments 16 and 17.	(1) antenna 1 has conspicuous hyaline membrane on segments 16 and 17.
(2) endopod of leg 4 with 2 terminal spines very unequal in length, the inner is much longer than the outer.	(2) terminal spines of endopod 4 are slightly different in length.
15. *M. albicans* (Smith 1909)	
(1) terminal 2 segments of antenna 1 without hyaline membrane.	(1) the last 2 segments of antenna 1 with hyaline plate.
(2) the last two joints of the inner ramus of all but the first pair have their internal margin serrated.	(2) the internal margin of endopods of the last 2 joints not serrated.
16. *M. emini* (Mrazek 1895)	
(1) dorsal seta unusually long extending beyond the innermost apical furcal seta.	(1) dorsal seta not longer than the outer apical furcal seta.
(2) antenna 1 long reaching the length of the whole anterior division;	(2) antenna 1 reaching to first thoracic segment.

posterior antenna unusually slender.	
(3) terminal spines of endopod 4 very unequal in length, the outer more than 1/3 as long.	(3) terminal spines of endopod 4 differ little in length.

17. *M. macracanthus* Kiefer 1929

(1) small, 920.0 in length for female.	(1) average 1256.0 in length for female.
(2) terminal joint of endopod 4, 3.5 times as long as wide; inner terminal spine 4 times as long as outer.	(2) terminal joint of endopod 4, 2.66 times as long as wide; inner terminal spine a little longer than outer.

18. *M. oblongatus* O. Sars 1927

(1) furcal rami 3 times as long as wide.	(1) furcal rami twice as long as wide.
(2) connecting plate of leg 4 on each side with a stout hook which has 3-4 small spines.	(2) connecting plate of 4th pair of legs on each side with a small spine-like projection.

19. *M. schmeili* (Poppe and Mrazek 1895)

(1) last two segments of antenna 1 without hyaline plate.	(1) with conspicuous hyaline plate.

(2) connecting plate of 4th pair of legs on each side with 4-5 small short hooks.	(2) connecting plate with simple projection on each side.

20. *M. retroversus* Kiefer 1929

(1) terminal joint of endopod 4, 3.5 times as long as wide; inner terminal spine 4 times as long as the outer.	(1) terminal joint of endopod 4, 2.66 times as long as wide.
(2) two small hooks with small spines on the connecting plate of 4th pair of legs, placed far apart from each other.	(2) a small projection on each side of the connecting plate.

21. *M. decipiens* Kiefer 1929

(1) small, female less than 1 mm. in length.	(1) average, female more than 1 mm. in length.
(2) on each side of the connecting plate placed a stout hook with small spines.	(2) with small projection.

22. *M. inopinus* (Kiefer 1926)	*M. leuckarti* from Borneo
(1) the hyaline membrane of the last 2 segments with whole edge.	(1) the hyaline membrane toothed.
(2) inner terminal spine of endopod 4 about twice as long as the outer.	(2) inner terminal spine of endopod 4 a little longer than the outer.
23. *M. rylovi* Smirnov 1928	
(1) furcal rami 3 times as long as wide.	(1) furcal rami twice as long as wide.
(2) inner terminal spine of endopod 4 twice as long as the outer.	(2) inner terminal spine of endopod 4 only a little longer than outer.
(3) connecting plate of the 4th pair of legs, on each side with a low, broad hook armed with few spines.	(3) connecting plate with small projection on each side.
24. *M. schuurmanae* Kiefer 1928	
(1) furcal rami 3 times as long as wide.	(1) furcal rami twice as long as wide.
(2) inner terminal spine of endopod 4, about 1/2 times as long as the terminal podomere.	(2) inner terminal spine of endopod 4 only a little shorter than the terminal podomere.

25. *M. infrequens* Kiefer 1929	*M. leuckarti* from Borneo
(1) terminal joint of the endopod 4, about 3 times as long as wide.	(1) terminal joint of the endopod 4, 2.66 times as long as wide.
(2) inner terminal spine twice as long as outer.	(2) inner terminal spine a little longer than outer.
26. *M. consimilis* Kiefer 1934	
(1) terminal spines of endopod 4 differ very much in length, outer : inner, 35.5 :14.2μ.	(1) outer spine : inner spine, 60 : 73.6μ.
(2) connecting plate of leg 4 with teeth on the protuberance and a row of teeth on the plate.	(2) connecting plate with simple projection without teeth.
27. *M. tobae* Kiefer 1933	
(1) dorsal furcal seta unusually long, about twice as long as the outer apical seta.	(1) dorsal seta of moderate length, not longer than the outer apical seta.
28. *M. nigerianus* Kiefer 1933	
(1) inner terminal spine of endopod 4 $2\frac{1}{2}$ times as long as outer.	(1) inner terminal spine of endopod 4 a little longer than outer.

(2) connecting plate of leg 4 with 2 large chitinous hooks which possess 4-5 spines.	(2) connecting plate with small simple projection.

29. M. annae Kiefer 1930

(1) furcal rami short, only about twice as long as wide.	(1) furcal rami, length : width, 2.5 : 1.
(2) the two terminal spines of the 4th endopodite are as long as the podomere.	(2) inner terminal spine a little shorter than the terminal podomere.

30. M. asiaticus Kiefer 1932

(1) inner terminal spine of endopod 4, 4-4.5 times as long as outer; 1/4-1/5 longer than podomere.	(1) the inner terminal spine only a little longer than outer.
(2) connecting plate with 2 large chitinous projection, the whole free edge covered with fine spines.	(2) connecting plate of leg 4 with simple small projection; free edge without spines.

31. M. thermocyclopoides Harada 1931

(1) small, body length 0.870 mm. for female.	(1) body length 1.256 mm. for female.

(2) furcal rami, length : width, 3.4 : 1.	(2) furcal rami, length : width, 2.5 : 1.

32. M. taihokuensis Harada 1931

(1) the hyaline plate of the terminal segments of antenna 1 has an entire edge.	(1) the hyaline plate is toothed.
(2) inner terminal spine of endopod 4 is 4 times as long as outer; outer one is longer than the podomere.	(2) the inner terminal spine a little longer than outer.

33. M. brevifurcatus Harada 1931

(1) connecting plate of leg 4 bears a pair of round hooks, each with 3 heavy spines on each side.	(1) connecting plate with simple small projection on each side.
(2) inner terminal spine of endopod 4 twice as long as outer.	(2) the inner terminal spine a little longer than outer.

34. M. ianthinus Harada 1931

(1) no hyaline membrane on terminal 2 segments of antenna 1.	(1) has hyaline plate on the terminal segments of antenna 1.

(2) connecting plate on each side with round protuberance which is armed with a few, usually 5 heavy spines; on the connecting plate near the posterior edge a row of thick stout spines.	(2) no spines on the protuberance.

35. M. operculifer Kiefer 1930

(1) several rows of fine teeth at each body segment.	(1) none
(2) connecting plate on each side with several spines.	(2) with only one spine-like projection on each side.
(3) outer terminal spine of endopod 4 twice as long as the inner.	(3) outer terminal spine shorter than inner.

36. M. trichophorus Kiefer 1930

(1) teeth at posterior edges of abdominal segments.	(1) no teeth at posterior edges of abdominal segments.
(2) inner edge of furca has hair.	(2) inner edge of furca naked.

37. M. tinctus Lindberg 1937

(1) Furcal ramus, length : width, 3.81 : 1.	(1) Furcal ramus, length : width, 2.59 : 1.

(2) Terminal joint of 4th endopodite, length : width, 37 : 26μ.	(2) terminal joint of 4th endopodite, length : width, 76.8 : 28.8μ.
(3) Basal lamella of 4th pair of legs, armed on each side with rounded projection bearing small spines.	(3) basal lamella of 4th pair of legs, armed on each side with small triangular projection.

38. M. stephanidesi Kiefer 1938

(1) terminal podomere of the 4th endopodite, length : width, 3.5 : 1.	(1) terminal podomere of the 4th endopodite, length : width, 2.66 : 1.
(2) the inner terminal spine a little shorter than the podomere, and over twice as long as outer one.	(2) the inner terminal spine only a little longer than the outer.
(3) the connecting plate of 4th pair of legs on each side with round projection armed with spinules.	(3) leg 4 connecting plate with small spine-like prominences.

39. M. microspinulosus Lindberg 1942

(1) connecting plate of 4th pair of legs on each side with evenly rounded lateral profection, rather	(1) connecting plate of 4th pair of legs with small spine-like prominences.

weakly projected and armed with very small spines.	
(2) inner terminal spine of 4th endopodite less than twice as long as outer one.	(2) inner terminal spine of 4th endopodite only a little longer than the outer one.
(3) 5th leg with apical spine longer than the seta.	(3) 5th leg with an apical spine shorter than the seta.

40. *M. incisus* Kiefer 1932

(1) terminal podomere of 4th endopodite, 3 times as long as wide.	(1) terminal joint of the endopodite 4, 2.66 times as long as wide.
(2) the inner terminal spine 2½ times as long as the outer, and somewhat longer than the podomere.	(2) inner terminal spine a little longer than outer.

B. Microcyclops sp.

Female-The body is slender; length about three times the greatest width. Cephalic and first thoracic segments are fused; the rostrum is small but distinct and appears obtuse in front. The metasome is slightly arched dorsally and longer than urosome. The second and third thoracic segments are about the same length; the fourth is shorter. The fifth segment is shorter and smaller than the fourth, and bears the fifth pair of legs ventro-laterally. The sixth segment (genital) is short, and swollen slightly in the middle. The body measurements are shown in Table 10.

TABLE 10

Measurements of *Microcyclops* sp. adult female.

Body length		0.757 mm.	(0.629----0.886 mm.)
Body width		228.8 μ	(185.9----286.0 μ)
Length of rami		41.6 μ	(38.4-----60.8 μ)
Width of rami		25.6 μ	(22.4-----28.8 μ)
Length of furcal setae (reading down from outer to inner.)	1	38.4 μ	(32.0-----57.6 μ)
	2	51.2 μ	(48.0-----64.0 μ)
	3	86.4 μ	(80.0-----112.0 μ)
	4	44.8 μ	(35.2-----86.4 μ)

The abdomen is three-segmented. The proportional lengths of the various segments are as follows:

6th abdom.	1st abdom.	2nd abdom.
48 μ	28.8 μ	35.2 μ

3rd abdom.	furca
38.4 μ	41.6 μ

The last segment of the abdomen has a row of spinules on both dorsal and ventral surfaces along the distal margin.

The caudal rami are parallel, not quite twice as long as wide, slightly shorter than the last abdominal segment; the inner edges without hairs. The rami are widest in the proximal regions, and narrow slightly posteriorly. A short dorsal seta is located near the distal end of each ramus. The lateral seta is only a very little behind the middle of the lateral edge. The most medial apical seta is almost as long as the most lateral or slightly longer. The inner middle apical seta is long, more than half the length of the body. The lateral middle apical seta about 59% of the length of the inner middle one. Four or more sharp spinules are located on the distal end of the ramus near the base of each most lateral seta (Fig. 29).

The anterior antenna has 12 podomeres (Fig. 16) reaching to the first thoracic segment; the line between four and five indistinct so that some specimens show only 11 podomeres. On podomeres 1-5 there are many setae of various lengths. A short row of slender pointed spines is set on the first podomere, near the basal end; and a very long seta arises from the middle

half of podomere 3. A short, stout spine is situated at the anterior distal angle of podomere 5. Podomere 7 is distinctly elongated, and the following three podomeres are short and not quite square. The proportional lengths of the podomeres are as follows:

Segment:	1	2	3	4	5	6	7
	64μ	12.8μ	19.2μ	9.6μ	6.4μ	19.2μ	38.4μ
	8	9	10	11	12		
	12.8μ	19.2μ	19.2μ	25.5μ	35.2μ		

The posterior antennae (Fig. 17) are shorter than the anterior pair, with four podomeres. The basal podomere is elongated, the other three almost the same length. The second podomere bears one seta ventrally, near the middle portion. The third podomere somewhat pyrifoum bearing setae of various lengths, about 8-9 in number. The terminal podomere is cylindrical bearing one pair of long and one pair of short setae apically. The proportional lengths of the podomeres are:

Segment:	1	2	3	4
	64μ	48μ	38.4μ	44.8μ

The mandibles (Fig.18) are stout, with 7 irregular teeth distally. On the outer basal area there are 3 setae, one short and two long which are about twice as long as the former. The labrum (Fig. 19) is distinct, with a row of irregular stout blunt teeth medially.

The first maxillae (Fig. 20) are small, terminally with about 4 teeth; and basally with an outer lobe bearing 4 setae,

all of approximately the same length, the middle 2 arising at the tip of the conical lobe. The inner lobe tipped with 2 setae, the outer one of which is plumose.

The second maxillae (Fig. 21) have 4 podomeres. The basal and the second podomeres, each with one seta on the ventral side. The third podomere has 3 setae and a strong recurved claw with a row of about 7 stout pointed teeth. The distal podomere is minute, consisting of a conical lobe tipped with long setae.

The maxillipeds have 3 podomeres (Fig. 22) ; the basal podomere is the longest, with 1 seta on the ventral side near the distal end, and 2 setae slightly behind it. The second podomere has 2 setae on the middle ventral portion, and 4 slender sharp teeth near the proximal end along the ventral edge. The terminal podomere has 2 pairs of curved setae, one pair twice the length of the other.

The first four pairs of swimming legs are biramous with 2 podomeres. The first podomere is short and the second podomere much longer. The spines of both rami are stout and pointed, with serrated margins. The spine formula is 3.4.4.3.

The first pair of legs (Fig. 23) has the first basal podomere bearing a single inner seta, and fringed on its outer margin with few slender spinules. The second basal segment bears an outer seta and internally is produced in a rounded lobe with a long, armed inner basal seta. There is a row of small spinules along the articulation of the two basal segments.

The second podomere is shorter than that of the other pairs. There is a notch on the middle part of the connecting plate between the 2 rami. The first podomere of the exopodite has a stout spine on the distal outer margin, and a plumose seta on inner distal edge. The outer margin is fringed with slender spinules while the inner margin is fringed with hairs. The second podomere of the exopodite has 1 terminal spine, 2 lateral spines, and 5 long inner plumose setae. The inner margin is fringed with hairs. Endopodite 1 is fringed with fine hairs along its outer margin and bears a plumose seta on inner margin. The second podomere of the endopodite bears a plumose seta at outer distal end, and 4 plumose setae along inner margin. Terminally there is a long stout terminal spine crowned with spinules at its base and a small spine-like projection about half as long just laterad to it.

The second pair of legs (Fig. 24) shows the first basal podomere fringed along the outer margin with long hair-like spinules and along proximal margin with hairs. The second basal podomere is fringed along the outer and proximal margins with spinules. The second podomeres of both exopodite and endopodite are long. The connecting plate between two rami is plain. The distal podomere of the exopodite has 3 outer and 1 terminal spines and 5 inner plumose setae. The endopodite has the distal podomere bearing one long stout terminal spine, an outer spine-like projection, and 5 outer lateral plumose setae. A row of spinules is located around the base of all

the stout spines. The basal podomere of the exopodite has spinules arranged in a semicircle on the latero-distal area and a row of long spinules along the outer margin.

The third pair of legs is similar to 2nd pair (Fig. 25).

The fourth pair of legs (Fig. 26) has hairs along the outer margins of basipodite and both exopodite and endopodite and also along the inner margin of the exopodite. The connecting plate of two rami is plain. The distal podomere of the exopodite has 2 lateral and 1 terminal spine and 5 inner plumose setae. The distal podomere of the endopodite is about twice as long as wide, bearing 3 outer and 1 inner plumose seta and one terminal spine which is more than half as long as the podomere. The arrangement of the spines and setae on the swimming legs is shown in Table 11. The measurements of the podomeres of the swimming legs are given in Table 12.

The distal podomere of the fifth pair of legs is small, tipped with a long seta and a slender well-developed medial spine (Fig. 27).

The sixth pair of legs is represented by two small spines on the ventro-distal portion of each side of the 6th thoracic segment (Fig. 28).

TABLE 11

Arrangement of spines and setae on the first 4 pairs of swimming legs of *Microcyclops* sp.

	outer term. inner					outer term. inner				
Legs	basp.		exopodite			endopodite			basp.	
	1	2	1	2	1	1	2	1	1	2
1st	-	S	P	2P P 5S	S	-	S P 4S	S	S	S
2nd	-	S	P	3P P 5S	S	-	S P 5S	S	S	-
3rd	-	S	P	3P P 5S	S	-	S P 5S	S	S	-
4th	-	S	P	2P P 5S	-	-	S P 3S	S	S	-

S = seta

P = spine

TABLE 12

Leg measurements of *Microcyclops* sp., female.

Legs	Exopodite			Endopodite		
	Podomere			Podomere		
	1	2	total length	1	2	total length
1st	38.4	44.8	83.2 μ	28.8	48.0	76.8 μ
2nd	41.6	73.6	115.2 μ	35.2	67.2	102.4 μ
3rd	38.4	76.8	115.2 μ	35.2	70.4	105.6 μ
4th	32.0	57.6	89.6 μ	38.4	64.0	102.4 μ

Male-The body is smaller in size. The anterior antennae (Fig. 30) are prehensile, with 17 segments. Because of the irregular size and shape of the podomeres it is difficult to determine the actual number. The first, fourth, and sixth podomeres each bear a long seta latero-distally. The first and eleventh podomeres are plump, while the fourth, fifth, and sixth are extraordinary short, and pressed together. The body measurements are shown in Table 13.

TABLE 13

Measurements of _Microcyclops_ sp. male.

Body length		0.729 mm.	(0.686---0.786 mm.)
Body width		228.8 μ	(214.5---257.4 μ)
Length of rami		48.0 μ	(44.8----48.0 μ)
Width of rami		22.4 μ	(19.2----25.6 μ)
	1	48.0 μ	(48.0----51.2 μ)
	2	257.4 μ	
	3	371.8 μ	(357.5---371.8 μ)
	4	70.4 μ	

The posterior antennae, mouth parts, and the swimming legs are like those in the female. The measurements of the swimming legs are shown in Table 14.

TABLE 14

Leg measurements of *Microcyclops* sp., male.

Legs	Exopodite			Endopodite		
	Podomere			Podomere		
	1	2	total length	1	2	total length
1st	25.6	32.0	57.6 µ	22.4	35.2	57.6 µ
2nd	28.8	51.2	80.0 µ	25.6	48.0	73.6 µ
3rd	25.6	54.4	80.0 µ	25.6	48.0	73.6 µ
4th	25.6	44.8	70.4 µ	25.6	44.8	70.4 µ

The abdomen is 4-segmented, the last segment short with a row of spinules around the distal margin. The proportional lengths of the posterior segments are:

6th thoracic	1st abdom.	2nd abdom.
70.4 μ	54.4 μ	44.8 μ

3rd abdom.	4th abdom.	Furcal branch
32 μ	16 μ	48 μ

The furcal rami are parallel, twice as long as wide. The innermost apical seta is longer than the outermost.

There is also semicircular arrangement of spinules on podomere 1 of the exopodites of the second third and fourth legs. The terminal podomere of the 4th endopodite is twice as long as wide, (44.8 x 19.2μ). The terminal spine is 41.6μ in length, almost as long as the podomere itself.

The fifth leg is similar to that of female. The terminal seta averages 150.4μ in length, and the medial spine, about 28.8μ .

The sixth pair of legs (Fig. 31) on the ventro-distal margin of the sixth thoracic segment is represented by a small lobe tipped with a short armed seta and a slender spine of the same length, 15.4μ .

The following is a summary of the distinctive characters of the female:

(1) Anterior antennae 12-segmented.

(2) Swimming-legs biramous, 2-jointed.

(3) 5th leg 2-jointed, tipped with a seta and a small medial spine.

(4) Furcal branch less than twice as long as wide, and shorter than the last abdominal segment.

(5) Most medial terminal furcal seta and the outer terminal furcal seta are almost the same length.

(6) The medial middle terminal furcal seta longer than the outer middle one and both feathered alike.

(7) Terminal podomere of endopodite 4 about twice as long as wide, tipped with a single spine.

(8) All spines of the 4 pairs of legs are stout and pointed, with the formula 3.4.4.3.

This species seems close to *M. malayicus* (Kiefer 1930) but differs in the following characters:

The lengths of furcal apical setae of *M. malayicus*, from inner to outer, are 66μ: 340μ: 210μ: 42μ. The anterior antenna is indistinctly 11-segmented. The terminal podomere of the 4th endopod is twice as long as wide (44 : 22μ)

and the terminal spine is as long as the podomere (43μ). The body length of female is 500μ, and male is unknown.

Comparison with other species in the subgenus:

1. Microcyclops moghulensis (Lindberg 1939)
    (1) furcal branch 3 times as long as wide.
    (2) terminal podomere of endopodite 4 tipped with 2 spines, the inner terminal spine a little less than twice as long as the outer.
2. M. varicans (O. Sars 1863)
    (1) Abdominal segment 5 with a series of rather large spines ventrally at base of ramus, often reduced to about 6 spines, not extending to sides.
    (2) furcal rami 3-4 times as long as wide.
    (3) inner apical furcal seta considerably longer than outer seta, and usually shorter than ramus.
    (4) terminal podomere of endopodite 4 tipped with 2 spines, the outer terminal spine shorter than the inner one.
3. M. subaequalis (Kiefer 1927)
    (1) both terminal spines on the podomere of 4th endopodite elongated with the medial one of them up to ¼ shorter than the podomere.
    (2) other characters close to M. varicans.
4. M. rubellus (Lillj. 1901)
    (1) lateral seta placed at the beginning of last fourth.
    (2) furcal ramus 2½ - 3 times as long as wide.
    (3) middle terminal furcal setae feathered differently.
    (4) leg 5 without inner spinule.

(5) terminal podomere of endopodite 4 tipped with 2 spines, the inner terminal spine somewhat longer than the outer one.

5. M. davidi (Chapp. 1922)
   (1) furcal rami 2½ times as long as wide.
   (2) most medial terminal furcal seta not quite twice as long as lateral.
   (3) leg 5 with one terminal seta, without inner spine.
   (4) terminal podomere of endopodite 4 tipped with 2 spines, the inner terminal spine 1/3 longer than lateral one.
6. M. paraplesius (Kiefer 1929)
   (1) furcal rami 5½ times as long as wide.
   (2) most medial terminal furcal seta twice as long as lateral.
7. M. furcatus (Daday 1905)
   (1) furcal rami 6 times as long as wide.
   (2) 5th leg with podomere twice as long as basal part, armed with terminal seta.
8. M. australis (King 1855)
   (1) hairs on medial edge of furcal rami.
   (2) both middle terminal furcal setae only slightly different in length.
   (3) most medial terminal furcal seta longer than lateral.
   (4) second and third swimming-legs 3-jointed.
   (5) Spine formula 3.3.3.3.

9. M. anceps (Rich 1897)

    (1) Furcal rami 3½-4 times as long as wide.

    (2) Most medial and terminal setae almost equal in length.

    (3) The medial terminal spine of the 4th leg endopodite is somewhat longer than the lateral.

10. M. crassipes (O. Sars 1927)

    (1) Furcal rami 3 times as long as wide.

    (2) Most medial terminal furcal seta twice as long as lateral.

    (3) 5th leg (?)

11. M. bicolor (O. Sars 1863)

    (1) Furcal rami 4-4½ times as long as wide.

    (2) two middle terminal furcal setae very stout, but strikingly short, differ in length only a little.

    (3) Most medial terminal furcal seta more than twice as long as outer, or nearly as long as ramus.

12. M. linjanticus (Kiefer 1928)

    (1) Furcal rami 3½ times as long as wide.

    (2) Middle terminal furcal seta 4 times as long as furcal rami.

    (3) 5th leg without noticeable small spine on medial edge.

13. M. falsus (Kiefer 1926)

    (1) Furcal rami little longer than twice as long as wide.

    (2) Most medial terminal furcal seta nearly ½ as long as lateral.

(3) The lateral terminal spine of the 4th endopodite reaches ½ the length of the medial one.

14. M. pachycomus (O. Sars 1909)
    (1) Anterior antennae 10-segmented.
    (2) Spines on exopodite and 4 endopodite are blunt.
    (3) 5th pair of legs rudimentary.

15. M. exiguus (O. Sars 1909)
    (1) 5th leg rudimentary, tipped with seta.
    (2) Lateral seta of furcal rami somewhat before the middle of the lateral edge.
    (3) Most medial terminal furcal seta twice as long as lateral.
    (4) 2 middle terminal furcal setae feathered differently.
    (5) Small, female 0.53 mm. in length.

16. M. caudatus (O. Sars 1927)
    (1) 5th leg armed only with one terminal seta.
    (2) Furcal rami less than 4 times as long as wide.
    (3) Most medial terminal furcal seta one third of the lateral.

17. M. inopinatus (O. Sars 1927)
    (1) Furcal rami less than 4 times as long as wide.
    (2) Terminal podomere of the 4th endopodite bears a slender spine which is longer than the podomere.

18. M. cunningtoni (O. Sars 1909)
    (1) 2 middle setae of furcal rami thorn-like fairly short.

(2) Most medial terminal furcal seta one third longer than the lateral, and spine-like.

(3) Lateral terminal spine of the 4th endopodite shorter than ½ the length of the medial one.

19. M. attenuatus (O. Sars 1909)

(1) Furcal rami longer than the last 2 abdominal segments.

(2) Most medial terminal furcal seta twice as long as lateral.

(3) 5th leg small, rudimentary, one joint, with one apical seta, medial edge somewhat angular.

(4) Anterior antennae 10-segmented.

20. M. gemellus (Gurn. 1928)

(1) inner terminal spine of endopodite 4 three times as long as lateral.

(2) Terminal podomeres of 3 and 4 endopodites elongated, about twice as long as wide.

21. M. gracilis (Lillj. 1853)

(1) Furcal rami 3 times as long as wide.

(2) Middle terminal furcal setae short; most medial terminal furcal seta not quite twice as long as lateral.

(3) Inner terminal spine of endopodite 4 extraordinarily long, the outer terminal spine about 1/3 as long.

22. M. necessarius (Kiefer 1914)

(1) Furcal rami 3½ times as long as wide.

(2) Only 2 terminal setae well developed.

(3) Of the 2 terminal spines of 4th endopodite, the medial

one twice as long as the lateral.

23. M. mendocinus (Wrzski 1893)
    (1) Genital segment distinctly widened in front, posteriorly abruptly narrowed, as long as 3 following segments together.
    (2) Furcal rami four times as long as wide.
    (3) Both middle terminal furcal setae relatively short, equal in length.
    (4) Most medial terminal furcal seta shorter than lateral.
    (5) Inner terminal spine of 4th endopodite twice as long as lateral.
24. M. leptopus (Kiefer 1927)
    (1) Terminal podomere of 4th endopodite 3.5 times as long as wide.
    (2) Seta on each side of 5th thoracic segment.
25. M. dengizicus (Lepeschkin 1900)
    (1) Furcal rami 5-6 times as long as wide.
    (2) Middle terminal furcal setae short, both differing little in length.
    (3) Leg 5 very broad, with one seta and a stout spine placed far medially.
26. M. panamensis (Marsh 1913)
    (1) Furcal rami weak, 5 times as long as wide.
    (2) Most medial terminal furcal seta shorter than outer.
    (3) Middle terminal furcal seta little different in length.

(4) Connecting plate of the 4th leg, on each side with 3 teeth.

(5) Leg 5 very broad with one seta and a stout spine placed far medially.

(6) 4th endopodite with 2 terminal spines.

27. M. minutus (Claus 1863)

(1) Furcal rami 4 times as long as wide.

(2) Most medial terminal furcal seta shorter than outer.

(3) Both middle setae short, little different in length.

(4) Spine formula 3.3.3.3.

28. M. monacanthus (Kiefer 1928)

(1) A little spine of 5th leg on the tip of podomere, placed down on the middle leg.

(2) Male unknown.

29. M. arnaudi (O. Sars 1908)

(1) Genital segment as long as the 3 following segments together.

(2) Furcal rami ½ as long as abdomen.

(3) Most medial terminal furcal seta shorter than the outer.

(4) Spine formula 2.3.3.3.

30. M. planus (Gurn. 1909)

(1) Furcal rami as long as last 2 abdominal segments or somewhat longer.

(2) Most medial terminal furcal seta shorter than outer.

(3) Anterior antennae 9 segmented.

(4) Body flattened dorso-ventrally.

31. *M. javannus* (Kiefer 1930)
    - (1) Furcal branch about 3 times as long as wide.
    - (2) The terminal podomere of the 4th endopodite with 2 short terminal spines, the inner one less than half the length of the podomere.
32. *M. feuerborni* (Kiefer 1933)
    - (1) Furcal branch 3 times as long as wide.
    - (2) The terminal podomere of the 4th endopodite, length : width, = 60 : 28μ.
    - (3) The lengths of 2 terminal spines, 63 : 32μ; the inner is a little longer than the podomere.
33. *M. sumatranus* (Kiefer 1933)
    - (1) Furcal branch more than 3 times as long as wide.
    - (2) Anterior antenna with 10 podomeres.
    - (3) The terminal podomere of the 4th endopodite tipped with 2 terminal spines which measured 60 and 31 .
34. *M. minimus* (Kiefer 1933)
    - (1) Furcal branch 3½ times as long as wide; the innermost apical seta a little shorter than the outermost.
    - (2) Terminal podomere of the 4th endopodite tipped with 2 terminal spines; the inner spine is shorter than the podomeres.
    - (3) Leg 5 small, with one podomere, only tipped with one apical spine.
35. *M. richardi* (Lindberg 1942)
    - (1) Furcal branch 2½ times as long as wide.

(2) Terminal joint of 4th endopodite a little less twice as long as wide; inner apical spine slightly longer than the outer.

36. *M. stammeri* (Kiefer 1938)

(1) Furcal branch, length : width, = 65 : 17μ.

(2) Outer terminal spine of 4th endopodite 30 in length, and the inner spine only half as long as the inner seta.

37. *M. subdolus* (Kiefer 1932)

(1) Furcal branch 3 times as long as wide.

(2) Anterior antenna 11-segmented.

(3) The 4th endopod, length : width, = 42 : 19μ.

38. *M. royi* (Lindberg 1940)

(1) Terminal joint of 4th endopod more than twice as long as wide, tipped with 2 terminal spines.

(2) The connecting plate of 4th legs with round lateral expansion projecting weakly above the free edge or not reaching it at all.

39. *M. tropicus* (Kiefer 1932)

(1) Furcal branch 3 times as long as wide.

(2) Terminal podomere of 4th endopodite about twice as long as wide. The inner terminal spine is twice as long as the outer.

40. *M. micropus* (Kiefer 1932)

(1) Anterior antenna 11-segmented.

(2) Terminal podomere of 4th endopod about 1½ times as long

as wide, and tipped with 2 terminal spines.

41. M. grandispinifer (Lindberg 1940)
    (1) Anterior antenna 11-segmented.
    (2) Connecting plate of the 4th pair of legs, with rounded lateral prominence making a slight projection above the free edge.
42. M. tanganicae (Gurn. 1928)
    (1) Furcal rami 4 times as long as wide.
    (2) Inner terminal spine of the 4th endopodite shorter than the podomere, but twice as long as the outer spine.
43. M. malayicus (Kiefer 1930)
    (1) The terminal spine of the 4th endopodite is as long as the podomere.
    (2) The anterior antenna of female is indistinctly 11-segmented.

VI. SUMMARY

The lists presented here show that more than 12 species of Copepoda serve as intermediate hosts for 12 species of nematodes of 3 families. More than 33 species of Copepoda carry 51 species of cestodes of 4 families. And more than 8 species of freshwater and marine Copepoda carry 12 species of trematodes of 4 families.

The data concerning Copepoda as intermediate hosts of helminths as given by me, is a supplement to Hall's (1929) work. Twenty-six species of copepods have been reported in the literature since Hall's paper as serving as intermediate hosts of 31 species of helminths. Admitting there are omissions, the list brings us to the conclusion that, among the crustaceans, the Copepoda are important intermediate hosts for Trematoda, Cestoda, and Nematoda.

Identification is made of two species of freshwater copepods from Borneo. The species from Selor, Borneo, was identified as Mesocyclops leuckarti (Claus 1857). It showed the following characters distinctive of this species:

1. Leg 1, basis without inner seta.
2. Anterior antenna of female with 17 segments; the hyaline membrane on the terminal podomere has a single large notch, while that on the 16th podomere is finely dentate.
3. Terminal podomere of 4th endopodite about 2.66 times as long as wide. The inner terminal

spine a little longer than the outer.

4. The connecting plate of the 4th legs with a small triangular spine-like projection on each side.
5. The medial spine of the 5th leg is a little shorter than the terminal seta.
6. Furcal rami more than twice as long as wide; inner margin naked. The innermost apical seta much longer than the outermost, about 241.9 : 82.8µ.
7. 6th leg is represented by two spines and a lateral plumose seta on the ventro-lateral surface of the 6th thoracic segment.

The general features of the species from Tarakan, Borneo, agree with those of the genus Microcyclops. It is distinguished from the other known species by the following characters:

1. Anterior antennae of female 12-segmented.
2. Swimming-legs biramous, 2-jointed; 5th leg 2-jointed, tipped with a seta and a small medial spine.
3. Furcal branch less than twice as long as wide.
4. Most medial terminal furcal seta and the outer terminal furcal seta of female are almost the same length.
5. Terminal podomere of endopodite 4 about twice

as long as wide, and tipped with a single spine.

6. The connecting plate of the 4th pair of legs has no projection on either side of the distal margin.
7. Sixth pair of legs of female represented by 2 small spines on each side of the ventral surface of the 6th thoracic segment; male with a medial spine and a lateral spine-like seta of the same length.
8. Spine formula 3.4.4.3.

VII. Abstract

Hall (1929) published the first systematic arrangement of arthropods as intermediate hosts of helminths. He found that 3 species of trematodes used 2 species of copepods as intermediate hosts, that 37 species of cestodes used 32 species of copepods as intermediate hosts, and that 6 species of nematodes used 8 species of copepods as intermediate hosts. His list contained a total of 34 species of copepods which serve as intermediate hosts for helminths.

Many life-cycles of parasitic worms have been worked out since 1929. In supplement to the work of Hall, it is now known that five more species of trematodes use five more species of copepods as intermediate hosts, that in the Cestoda 15 more species use 12 more species of copepods as intermediate hosts, and that 11 more species of Nematoda make use of 9 more species of copepods. Altogether twenty-one species of copepods serve as intermediate hosts for thirty-one species of helminths, these figures being in addition to those reported by Hall.

Mesocyclops leuckarti (Claus 1857) was identified from Selor, Netherlands Borneo. The original descriptions of the forty-one known species of Mesocyclops have been studied and compared with the specimens from Sarawak and Sandakan, Borneo, show characters identical with the Selor specimens.

Microcyclops sp. was identified from Tarakan, Netherlands Borneo. The original descriptions of the forty-

three known species in the genus were studied and compared with these specimens.

The anterior antenna of female is 12-segmented, while that of male is 17-segmented. The first 4 swimming legs are biramous and 2-jointed. The second basipodite has an inner seta. The fifth leg is small and tipped with a seta and a medial spine. Furcal branch is short (41.6 x25.6 μ). The terminal podomere of the 4th endopodite is more than twice as long as wide (64 x 25.6 μ), and tipped with a single terminal spine (54.4 μ). The spine formula is 3.4.4.3.

This species seems closest to *Microcyclops malayicus* (Kiefer 1930), but differs. The body size (0.629-0.886mm.) is longer than *Microcyclops malayicus* (0.500 mm.). The furcal apical setae and terminal podomere of the 4th endopod are also longer. The terminal spine of the 4th endopodite is shorter than the podomere, while that of *Microcyclops malayicus* is almost as long as the podomere. The anterior antenna of *Microcyclops malayicus* female is indistinctly 11-segmented; and male is unknown.

BIBLIOGRAPHY

* Beal, F. E. L.
1881. A shower of *Cyclops quadricornis*.
Amer. Nat. XV, P. 736.

Bonne, C.
1942. Researches on sparganosis in the Netherlands East Indies.
American Journal of Troical Medicine 22(6):643-645

Brackett, Sterling
1935. Description and life history of the nematode *Dracunculus ophidensis* n. sp., with a redescription of the genus.
Journal of Parasitology 24(4):353-360.

Cable, R. M. and Hunninen, A. V.
1941. The systematic position of the genus Deropristis Odhner, with respect to a proposed revision of the Trematode families Acanthocolpidae and Allocreadiidae.
Journal Parasitology 27 Suppl. Abstr. P. 14.

Callet, J., et C. Desportes
1934. Sur le cycle evolutif de *Schistocephalus solisus* (O.-F. Muller).
Annales de Parasitologie Humaine et comparee 12(1):35-39.

Dawes, Ben
1946. The Trematoda.

Desportes, C.
1938. *Filaria oesophagea* Polonio 1859, Parasite de la couleuvre d'Italie, est un Dracunculus tres voisin de la filaire de Medine.
Annales de Parasitologie Humaine et comparee 16(4):304-326.

* Giesbrecht, W.
1899. Die Asterscheriden.
Fauna u. Flora Neapel. Monog. 25, PP. vi, 217,11 pls.

* Gjorgjewic, Z.
1907 Les organismes du plankton des grands lacs de la Peninsule Balkanique.
Mem. Soc. Zool. Fr. XX PP. 5-19.

Gurney, Robert
1931. British Fresh-Water Copepoda, volumes I,II,III.

Hall, Maurice
1929. Arthropods as intermediate hosts of helminths.

Harada, Isokiti
1931. Studien uber die Susswasserfauna Formosas, IV. Susswasser-Cyclopiden aus Formosa.
Annotationes Zoologicae Japonenses 13(3):149-168.

Hedrick, Leslie R.
1935. The life history and morphology of *Spiroxys contortus* (Rudolphi): Nematoda: Spiruridae.
Transactions of the American Microscopical Society 54(4):307-335.

Herde, Karl E.
1938. Early development of *Ophiotaenia perspicua* LaRue.
Transactions of the American Microscopical Society 57(3):282-291.

Hjortland, Arthur Lorimer
1928. On the structure and life history of an adult *Trienophorus robustus*.
Journal Parasitology 15(1):38-44.

Hunter, George W.
1929. Life history studies on *Proteocephalus pinguis* LaRue.
Parasitology 21(4):487-496.

Kiefer, Friedrich
1929. Zut Kenntnis einiger Artengruppen der Susswasser-Cyclopiden.
Zeitschr. Wiss. Zool. 133, PP. 1-56.
-- 1930. Neue Ruderfubkrebse von den Sunda - Inseln.
Zoologischer Anzeiger, 86, 185-189.
-- 1930. Zur Kenntnis der freilebenden Copepoden Madagaskars.
Zoologischer Anzeiger 87, 42-46.
-- 1930. Ein Neuer Mesocyclops ans Java.
Zoologischer Anzeiger 90, 86-92.
-- 1930. Neue Cyclopiden von den Sunda-Inseln.
Zoologischer Anzeiger.
-- 1932. Neue Diaptomiden und Cyclopiden aus Franzosisch-Westafrika.
Buletinul Societatii de Stiinte diu Cluj.
-- 1933. Freilebende Binnengewasser copepoden.
Archiv fur Hydrobiologie 26(1), 121-142.
-- 1933. Susswassercopepoden aus Brasilien.
Zoologischer Anzeiger 105($\frac{1}{2}$):38-43.
-- 1933. Die freilebenden Copepoden der Binnengewasser von Insulinde.
Archiv fur Hydrobiologie Suppl. Bd.: Tropische Binnengewasser 12, 519-621.

Kiefer, Friedrich
1934. Die freilebenden Copepoden Sudafrikas.
Zoologische Jahrbrucher 65(2):99-192.

Krull, Wendell H.
1935. Study on the life history of *Halipegus occidualis* Stafford, 1905.
American Midland Naturalist 16(2):129-142.

Larsh, John E., Jr.
1941. Corallobothrium parvum n. sp., a cestode from the common bullhead, *Ameiurus nebulosus* Le Sueur.
Journal of Parasitology 27(3):221-226.

Li, H. C.
1935. The Taxonomy and early development of *Procamallanus fulvidraconis* n. sp.
Journal of Parasitology 21(2):103-113.

Lindberg, Par-Knut
1941. Cyclopoides nouveaux du continent Indo-Iranien.
II Records of the Indian Museum 43(3):259-264.
-- 1942. Cyclopoides nouveaux du continent Indo-Iranien.
III-IV. Records of the Indian Museum 44(1):15-27.

Magath, Thomas B.
1928. The early life history of *Crepidobothrium testuda* (Magath 1924).
Annales of Tropical Medicine & Parasitology 23(1):121-128.

Michajlow, W.
1932. (Les adaptations graduelles des Copepodes Comme premiers hotes intermediaires de *Triaenophorus nodulosus* Pall.
Annales de Parasitologie Humaine et comparee 10(4):334-344.

Miller, Richard B.
1945. Note on *Triaenophorus nodulosus* (Pallas) in the 2nd intermediate host.
Canadian Journal Research Section D. Zoological Science 23(1).
-- 1945. Studies on Cestodes of the genus Triaenophorus from fish of Lesser Slave Lake, Alberta.
Science 23(4):p. 105-115.
-- 1945. Description and life history of *Triaenophorus stizostedionis* n. sp.
Canadian Journal Research Section D. Zoological Science 23(5) p. 117-127.

Moorthy, V. N. and W. C. Sweet
1937. *Camallanus sweeti* n. sp., a new sp. of Camallanidae (Nematoda).
Journal of Parasitology 23(3):302-306.
-- 1938. Further notes on the experimental infection of dogs with dracuntiasis.
Amer. Jour. Hyg. 27(2):301-310.
-- 1938. Observations on the life history of *Camallanus sweeti*.
Journal of Parasitology 24(4):323-337.

Mueller, Justus F.
1938. The life history of *Diphyllobothrium mansonoides* Mueller 1935 and some considerations with regard to sparganosis in the United States.
American Journal of Tropical Medicine 18(1):41-57.

Ruszkowski, J. S.
1932. Le Cycle evolutif du Cestode *Drepanidotaenia lanceolata*.
Bulletin International De Academie Polonaise Des Sciences et des Lettres
Classe des Sciences Mathematiques et Naturelles
Serie B: Sciences Naturelles (II).

Thomas, Lyell J.
1929. *Philometra nodulosa* nov. spec. With notes on the life history.
Journal of Parasitology 15(3):193-198.
-- 1931. Notes on the life history of *Ophiotaenia saphena* from *Rana clamitans* Latr.
Journal of Parasitology 17(4):187-195.
-- 1932. American Society of Parasitologists. *Cercaria sphaerula* infecting *Cyclops vulgaris*.
Journal of Parasitology 19(2):156-180 P. 165.
-- 1934. *Cercaria sphaerula* n. sp. from *Helisoma trivolvis* infecting Cyclops.
Journal of Parasitology 20(5):285-290.
-- 1937. Environmental relations and life history of the tapeworm *Bothriocephalus rarus*.
Journal of Parasitology 23(2):133-150.

Villers-sur-Mer
1930. Helminthes recoltes dans la region.
Societe Linneenne de Normandie, Caen. Bulletin, series 8, volume 3, pp. 7-12.

* Indicates this book has not been seen by the writer.

Explanation of Plate 1.

Mesocyclops leuckarti from Broneo

Female:

Fig. 1 - anterior antenna.

Fig. 2 - posterior antenna.

Fig. 3 - mandible.

Fig. 4 - first maxilla.

Fig. 5 - second maxilla.

Fig. 6 - maxilliped.

Fig. 7 - labrum.

Fig. 8 - first leg.

Fig. 9 - second leg.

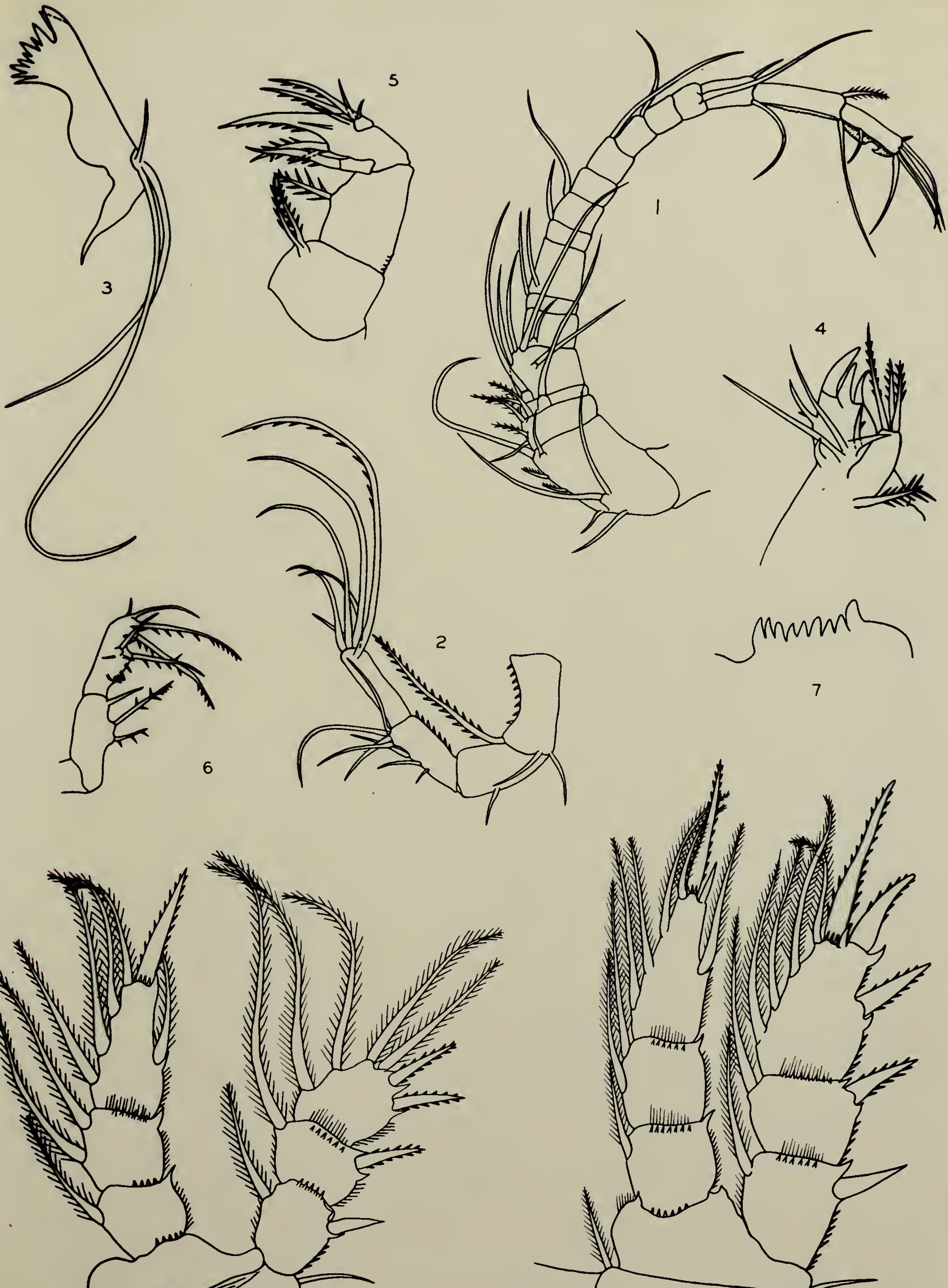
All figures drawn with the aid of a camera lucida.

Scale A applies to Figs. 3,4,7,13,27,31,29, and 20.

Scale B applies to Figs. 8,9,10,11,12,14,18,19,23, 24,25, and 26.

Scale C applies to Figs. 2,6,5,15,21,22, and 28.

Scale D applies to Figs. 1,16,17, and 30.



Explanation of Plate 2.

Mesocyclops leuckarti

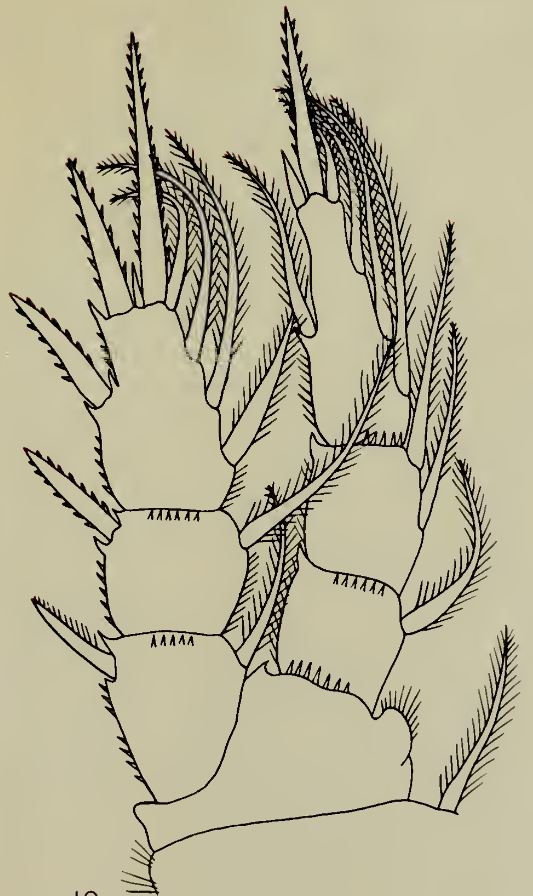
Female: (continued)

Fig. 10 - third leg.
Fig. 11 - fourth leg.
Fig. 12 - fifth leg.
Fig. 13 - sixth leg.
Fig. 14 - furcal rami.
Fig. 15 - anterior antenna (male).

Microcyclops sp. from Borneo

Female:

Fig. 16 - anterior antenna.
Fig. 17 - posterior antenna.
Fig. 18 - mandible.
Fig. 19 - labrum.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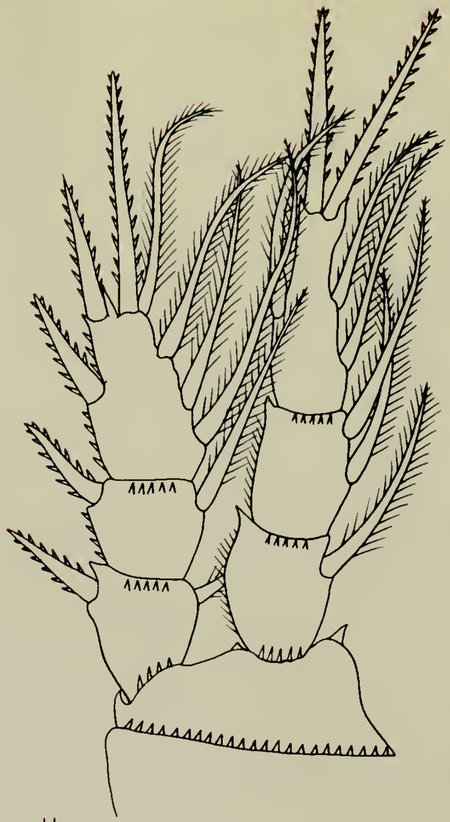
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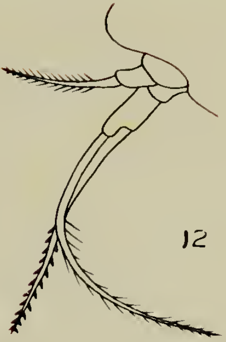
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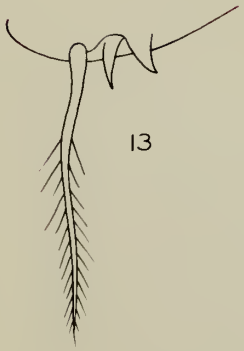
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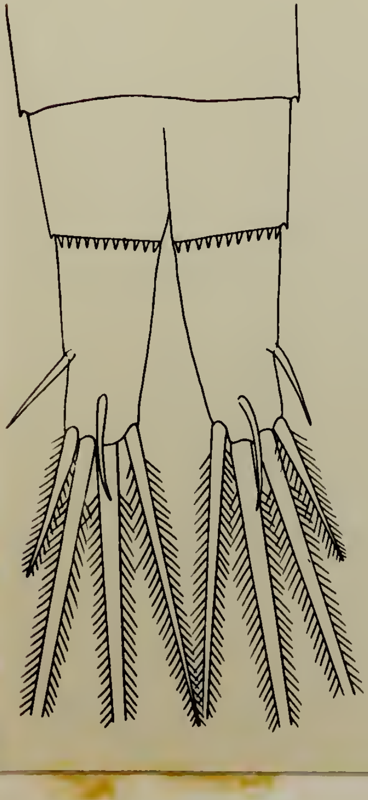

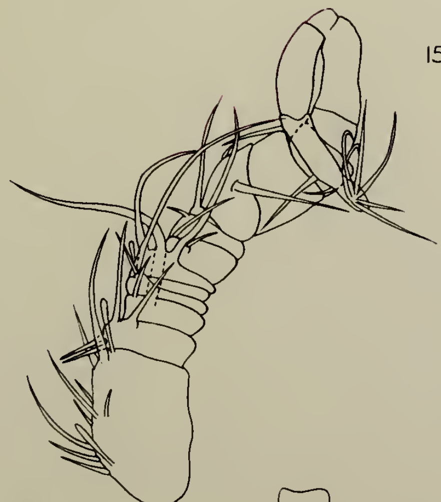
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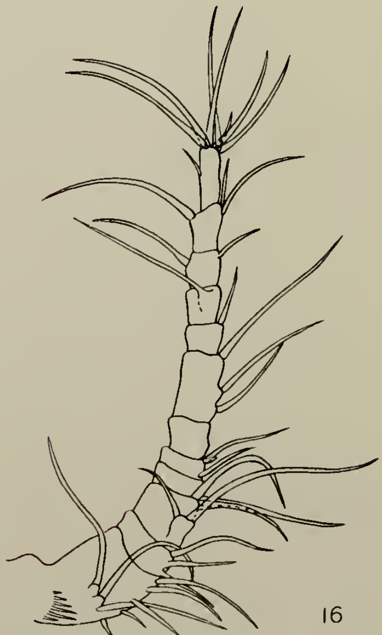
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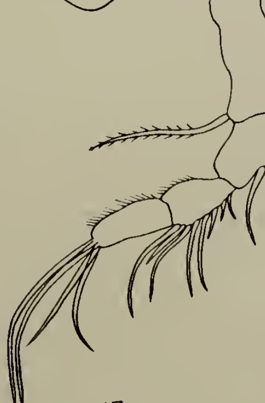
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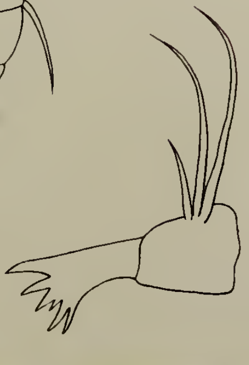
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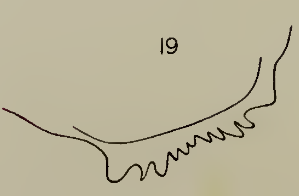
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Explanation of Plate 3.

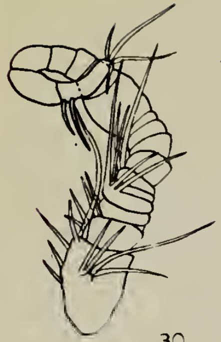
Microcyclops sp. from Borneo

Female:

Fig. 20 - first maxilla.
Fig. 21 - second maxilla.
Fig. 22 - maxilliped.
Fig. 23 - first leg.
Fig. 24 - second leg.
Fig. 25 - third leg.
Fig. 26 - fourth leg.
Fig. 27 - fifth leg.
Fig. 28 - sixth leg.
Fig. 29 - furcal rami.

Male:

Fig. 30 - anterior antenna
Fig. 31 - sixth leg.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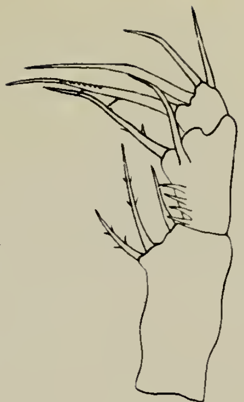
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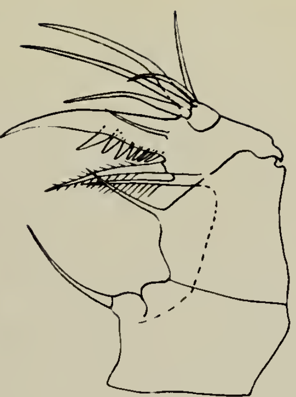
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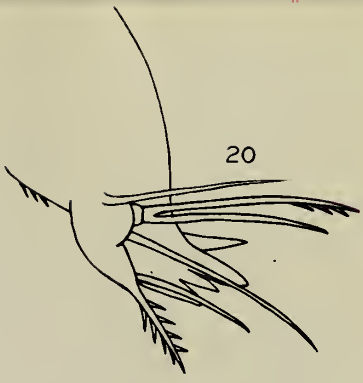
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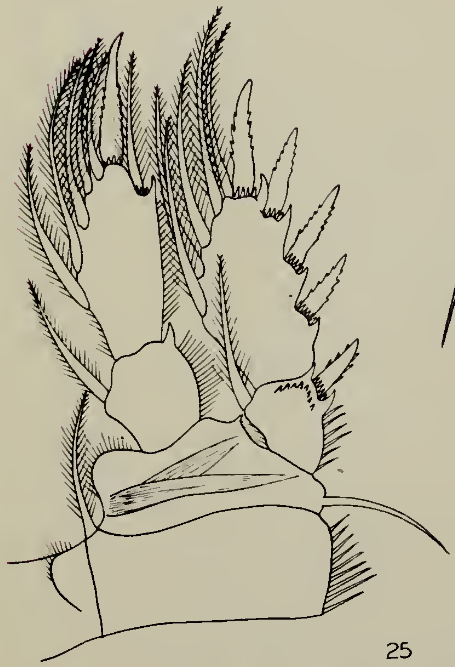
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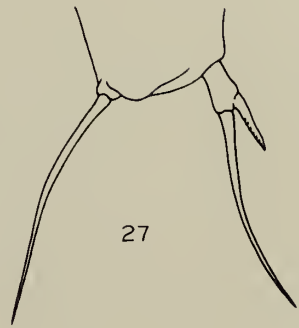
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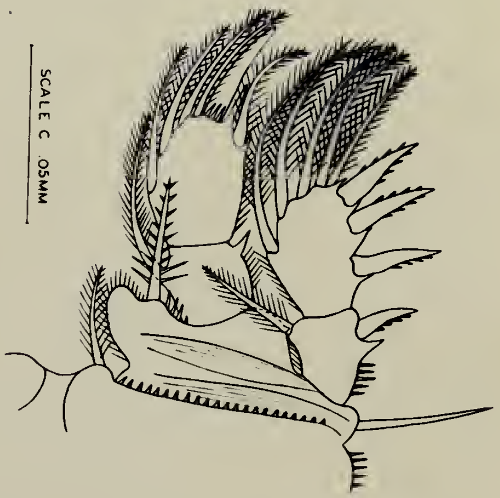
SCALE C .05MM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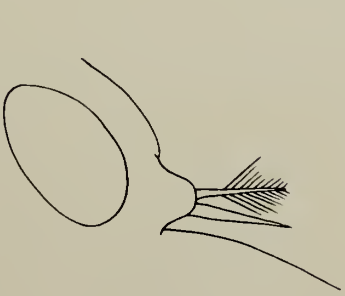
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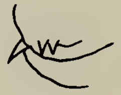
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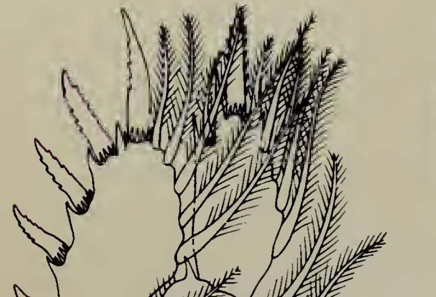
SCALE A .05MM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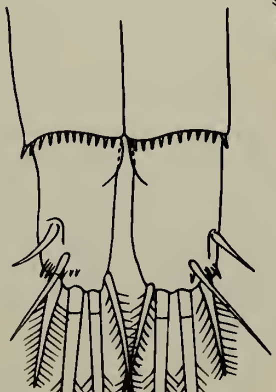
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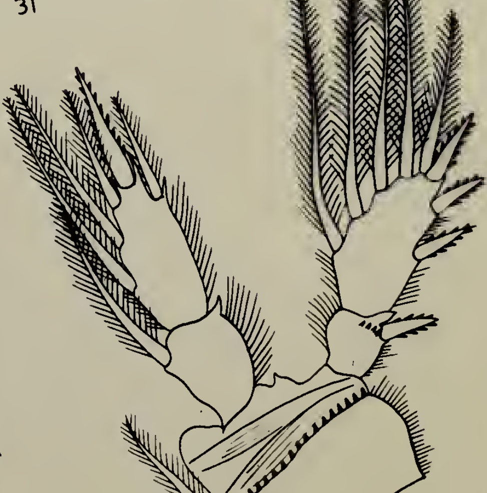
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